SCIENCE ABSTRACTS.

Section A.—PHYSICS.

JULY 1919.

GENERAL PHYSICS.

823. *Geometrical Model for the Orthogonal Projection of the Sines and Cosines of Complex Angles.* **A. E. Kennelly.** (Am. Acad., Proc. 54. pp. 871–878, April, 1919.)—In the model described, the sine or cosine of a complex angle, either hyperbolic or circular, can be produced by two successive orthogonal projections on the XY plane, one projection being made from a rectangular hyperbola, and the other projection being then made from a particular circle definitely selected among a theoretically infinite number of circles, all concentric at the origin O, which circles, however, are not co-planar. The selection of the particular circle is determined by the foot of the projection from the hyperbola. Photographs of the model are given, with a description of the method of use in particular cases. A. W.

824. *Ionisation Manometer.* **M. So.** (Phys. Math. Soc. Japan, Proc. 1. pp. 76–87, April, 1919.)—Buckley [Abs. 572 (1917)] has described an ionisation manometer which makes use of the ionisation of gas by an electron discharge. The present paper gives an account of an investigation of the working of such manometers. It is shown that the equation $C_+/C_- = KP$ holds good within the pressure-range from 10^{-3} to 10^{-5} mm. of mercury, C_+ denoting the collector current, C_- the anode current, and K being a constant having a value of about $0{\cdot}3 \times 10^{-2}$ to about $2{\cdot}6 \times 10^{-2}$, depending on the anode and collector potentials. The higher values of K are found with the higher anode potentials. A. W.

825. *Refinements in Spherometry.* **G. W. Moffitt.** (Eastman Kodak Co.'s Research Lab., Comm. No. 78. Phys. Rev. 13. pp. 261–271, April, 1919.)—Improvements in the measurement of lens surfaces have not kept pace with the development of processes for shaping the surfaces. The new methods suggested are grouped under various headings. I. *Mechanical Methods.* (*a*) An improvement on the ring type of spherometer consists of a V-shaped circular groove. In the groove are three equal balls, equi-spaced. On the basis of certain assumptions given, the max. error to be expected on a small area would be 0·03 mm in using this ball ring and

0·15 mm. for an ordinary ring. A further advantage in the method is that this improved type of instrument is more durable than the older type. (*b*) Another new instrument is the single-contact sliding stage spherometer. Here the ring is dispensed with and the central contact rod slides up and down in front of a microscope. The horizontal movement corresponding to this vertical one is provided by a micrometer screw which moves the lens surface under the central contact rod. The advantages claimed for this instrument are :—(1) Less error in one spherical contact than in four. (2) The instrument provides a means of studying deviation of the surface from the spherical form. (3) An area too small to be determined by an ordinary spherometer can be measured.

II. *Optical Methods.* (*a*) Auto-collimating methods. In front of a simple reading telescope is placed a lens similar to the objective of the telescope. Between the two lenses is a half-silvered mirror at 45° to reflect a distant source. This arrangement gives a good field of view. The instrument works in the usual auto-collimating way. Difficulties arise due to spherical aberration, so the above arrangement can be improved as follows: Mount the lens to be measured on a nodal slide arrangement—the scale and vernier for measuring displacement are now on the turntable of the nodal slide. (*b*) Caustic curve methods. These are based on the aberrations produced by oblique reflection from the surface. These methods are valuable where the element of surface is too small for measurement by other methods. A microscope is set with its axis along the chief reflected ray, which is deflected by reflection 90°. If the microscope is moved along its axis the two astigmatic images perpendicular to one another are seen one after the other. The distance between these multiplied by $2\sqrt{2}$ is equal to the radius of the reflecting surface. On concave faces, where high magnification may be used, high precision is attainable. Thus a radius of 100 mm. may be found within a few hundredths of a millimetre. P. E. S.

826. *Strength of Quartz.* **G. Berndt.** (Deutsch. Phys. Gesell., Verh. 21. 5 and 6. pp. 110–117, March 30, 1919.)—The compression strength of fused quartz was determined, as in the previous experiments [Abs. 117 (1919)], on cylindrical specimens, 5 mm. in diam. and height, polished, taken from a rod of fused quartz, parts of which were quite free of bubbles; these latter gave higher values, but small bubbles had little influence. With the stress parallel to the optical axis, the average compression strength was 25,000 kg./cm.^{2} (28,000 max.), at right angles to the axis 22,800 (27,400 max.) ; these values are 20 % below those for quartz crystals ; some specimens split during the tests.

The tensile tests were made on rods 100 mm. long, 1 mm. diam. ; as they frequently broke within the grips or close to them, the central portion was ground down to a concave body of half the thickness; it is, as Sella and Voigt had observed in 1898, most essential to ensure perfectly central gripping. When a specimen failed, a wedge broke out, the edges of which formed angles of about 45° with the longitudinal axis; similar wedges have been observed with glass, but the angle is only of a few degrees in that case. The tensile strength was 1160 (1210 max.) kg./cm.^{2} parallel, and 850 (930 max.) with the optical axis at right angles to the rod axis. The tensile strength of quartz crystals had not been determined by Voigt, as he could not find any suitable cement for clamping the specimen.

Bending tests were made by the author by placing rods, 10 mm. sq. 120 mm. long, on two knife-edges and applying pressure to a third knife-edge resting on the middle of the bar ; the bending strength found was 1400 (1790 max.) kg./cm.^{2} with the optical axis parallel to the rod axis, and 920 (1180 max.) with the two axes at right angles. In the former case (axes parallel) the wedge fracture mentioned was again observed, and sometimes the fracture was pyramidal; in the latter case the specimens split in various directions or showed a clean fracture which seemed to be connected with some irregularity; the application of the load to the central knife-edge would be objectionable according to Voigt, who had, however, found very similar values for crystal. F. A. Schulze's value for the bending strength of fused quartz, 689 kg./cm.^{2}, is much lower; his specimen contained air-bubbles. The author further determined the hardness after Martens by scratching the specimen with a loaded conical diamond, apex angle 90°; the load figures were 73·8 and 59·2 kg./cm.^{2} for scratching parallel and at right angles to the optical axis. H. B.

827. *Stress Lines in Steel after Permanent Deformation.* **A. McCance.** (Inst. Eng. and Shipbuilders, Trans. **62.** pp. 2–16; Disc., 16–17, April, 1919.)—Deals with the determination of hardness and the use of the figures obtained as an indication of stress distribution resulting from cold work. A distinct relationship is found between the increased hardness resulting from cold work and the stresses induced by this cold work. The effect of shoulders on test-pieces is illustrated, and it is shown that in the case of rounded shoulders the stress lines are either straight across the specimen or are gently sloped, while in the case of test-pieces with sharp corners the most severe stress is located at the corners. The concentration of stress at the edges of a hole in a plate submitted to tension is readily demonstrated by the determination of the variation in hardness. When a steel plate is sheared, the edge of the plate after shearing is in a highly cold-worked condition, and it is decidedly harder and more brittle than the normal material. The distribution of stress can be readily obtained by determining the hardness on the plate and scrap from it; the hardening at the edge is found to extend into the plate by an amount almost equal to half the thickness. The increase in hardness at the extreme edge amounts to 60 %, and this hard layer cannot stand any further extension without the rupture extending inwards and forming cracks. All plates which have to be bent cold should have an amount equal to ¼ or ⅓ the thickness removed, if they have been sheared to size before their shape is altered in any way. In cases where it is not imperative to remove this layer annealing of the plate after shearing may be practised. Diagrams are given showing the distribution of stresses in impact test-pieces, and also illustrations showing the value of this method of determining the stress distribution in cases of failure of materials. C. O. B.

828. *Elastic After-effect in Metals.* **H. v. Wartenberg.** (Deutsch. Phys. Gesell., Verh. **20.** pp. 113–122, Aug. 30, 1918.)—Deformation of a metal produced by stresses below the elastic limit, is removed only gradually after, and not immediately on, taking off the load. The ratio of the deformation remaining after a definite interval of time subsequent to the removal of the load to the total deformation produced by the load has been called the elastic "after-effect" by Kohlrausch. The after-effect is proportional to the magnitude of the elastic deformation and to the time of action of the stress producing the deformation; it increases with rise of temperature and is greater in soft than in hard metals. In solid solutions the after-effect is greater than in either of the constituent metals. Many hypothetical theories have been put forward to account for the phenomenon, and none of them are quite satisfactory. According to the author, deformation below the elastic limit causes certain favourably disposed crystals to become overstressed either by sliding over each other or by internal slip along the gliding planes. On removing the load, the elastic stresses in the unaffected crystals tend to bring the displaced crystals back to their original positions gradually. The above observations are confirmed by torsion tests carried out on tungsten and zinc wires, while experiments with specially prepared wires consisting of a single crystal showed no after-effect—an important confirmation of the author's theory. The cause of the after-effect in organic threads like silk and in materials like glass is still an open question. Nor does the theory account for true elastic hysteresis in metals. True elastic hysteresis is independent of time and degree of deformation and is most probably similar to magnetic hysteresis. F. C. A. H. L.

829. *Temperature and the Molecular Surface Energy of Liquids between* — 80° *and* 1650°. **F. M. Jaeger.** (Zeits. Anorg. Chem. 101. pp. 1–214, Nov. 13, 1917.)—A preliminary account of determinations made in the years 1913–1916 on about 50 inorganic substances in the molten state at temperatures up to 1650° and on 200 organic substances between — 80° and + 250°. The capillary glass-tube method could be used only at relatively low temperatures, since the glass was attacked. None of the other methods proving satisfactory, the author applied the method of Simon and Cantor which he had previously tried in the Geophysical Laboratory at Washington. A capillary tube, 0·5 mm. diam., of platinum or Pt-Ir, is dipped into the liquid and a bubble of pure nitrogen is produced at its end; the bursting pressure of this bubble is measured. The apparatus and the elaborate precautions taken are described. The connection between the capillary and the pressure gauge is made through several spirals of Pt and Al (to meet expansion effects), and the liquid in contact with the mercury is normal octane (to prevent corrosion of the mercury) which is recommended for such work. The quantities determined with density d of the liquid, a hydrostatic balance being used for measuring the density of the molten substances; the surface tension $\chi = rH/2$, where H is the bursting pressure and r the radius of the capillary; the molecular surface energy $\mu = \chi(M/d)^{1/3}$ where M is the molecular weight; the temperature coefficient $d\mu/dt$, the specific cohesion $A^2 = 2\chi/g.d$, and the quantity A^2M/T. For normal (non-associated) liquids $d\mu/dt$ should be constant, 2·25 ergs per 1 deg. (van der Waals) and smaller for associated liquids. This is only partly confirmed, and it is concluded that the surface energy must partly be kinetic. Walden's rules (Molecular cohesion/Melting-point) = 3·65, and (Molecular cohesion/Boiling-point) = 1·15, do not hold more than approximately either. In a series of chemically-related compounds μ increases generally with the molecular weight; unsaturated compounds have higher μ than saturated compounds; aromatic para-compounds have larger μ than ortho- and meta-compounds; many stereo-isomers differ strongly in this respect. The μ/t curve of anisotropic liquids consists of two branches, and a sharp minimum marks the point where the anisotropic liquid crystal passes into the normal liquid. But there are many exceptions; thus the surface tension of the alkali halides decreases as the atomic weight increases. This holds for metallic compounds with electro-negative elements generally, and metallic compounds are exceptional in this as in many other respects. At high temperatures the law of corresponding states probably cannot hold for molten salts which are highly ionised, and the rule of Eötvös, that a low $d\mu/dt$ indicates a high degree of association, cannot be maintained.

The paper is largely tabular. H. B.

830. *Camphor Motions and Allied Phenomena.* **J. Geppert.** (Phys. Zeits. 20. pp. 78–88, Feb. 15, 1919.)—Reviews and discusses a number of phenomena of the kind indicated in the title. The phenomena are believed to depend chiefly on the expansion of the surfaces concerned; in the case of solutions, however, there are difficulties in the explanation. E. H. B.

831. *Thermodynamics of Capillarity.* **A. March.** (Ann. d. Physik, 58. 6. pp. 515–522, April 25, 1919.)—A theoretical treatment, with special reference to the temperature coefficient of surface tension. A. W.

832. *Crystalline Structure and Axial Ratio of Ice.* **F. Rinne.** (Sächs. Gesell. Wiss., Ber. [Math-phys. Kl.] 69. pp. 57–62, Feb. 26, 1917. Chem. Zentralblatt, ii. p. 671, 1917.)—With the aid of apparatus previously described the author confirms Nordenskiöld's statement that ice is hexagonal-hemimorphic (bipyramidal), the axial ratio being $a : c = 1 : 1{\cdot}6$. This result is in agreement with Rinne's law of isotypism, and ice would follow the magnesium type. H. B.

833. *New Method of Weighing Colloidal Particles.* **E. F. Burton.** (Roy. Soc., Proc. 95. pp. 480–483, June 4, 1919.)—The simple Stokes' law formula is of very narrow application to aqueous solutions, because the fall of particles smaller in radius than about 10^{-5} cm. is masked by the Brownian movement, which, as a result of molecular agitation, prevents any settling of the colloidal particles. The method outlined in the present paper may be described as an artificial production of settling due to gravitation by superimposing the motion produced in an electric field maintained in the liquid medium upon that due to gravitation. Results obtained for colloidal silver particles are in good agreement with those obtained by the counting method. [See Abs. 968 (1906).] A. W.

834. *True Barometric Pressure in a Rapid Current of Air.* **J. G. Coffin.** (Phys. Rev. 13. pp. 317–319, April, 1919. Abstract of paper read before the Am. Phys. Soc., March, 1919.)—The accuracy of the measurement of barometric pressure in rapidly-moving aeroplanes is open to serious question. If a body of any shape is moving rapidly through the air, there are regions on the surface of it which receive an aërodynamic pressure greater than the normal static or barometric pressure, and there are also regions under smaller pressure than normal. This difficulty has been surmounted as follows:—Place a barograph inside a small sphere, which is rotated by clockwork, and has one hole to the exterior. Then the graph traces a characteristic curve from which the true pressure, as obtained from an instrument at rest, is easily deduced. E. H. B.

835. *Laws of Flow of a Liquid by Drops from Cylindrical Tubes.* **L. Abonnenc.** (Comptes Rendus, 168. pp. 556–557, March 17, 1919.)—Obtains a formula for the mass of liquid which passes by drops from a cylindrical tube. It is shown to involve the first and second powers of the frequency of fall of the drops. E. H. B.

836. *Reflection of Mercury Molecules at a Gold Surface at Low Temperatures.* **J. Weyssenhoff.** (Ann. d. Physik, 58. 6. pp. 505–514, April 25, 1919.)—The reflection of gas molecules at solid surfaces has been one of the main problems of recent experimental investigations of the kinetic theory of gases.

Knudsen has shown that the direction distribution of the reflected molecules per unit solid angle is proportional to the cosine of the angle of reflection and independent of the direction of the incident molecules. This rule was confirmed later by Knudsen and Wood [see Abs. 457 (1916)]. For angles of reflection exceeding 80°, Wood found deviations which he sought to explain by inequalities of the glass surface used. There still remains unsolved the wider question of the energy-change of the molecules through impact at the surface. This problem is complicated by the temperature conditions and becomes still more complex when the molecules condense on the reflecting surface. During the last few years much work has been done on this subject, and the author briefly discusses the principal results attained. He then describes his own experiments, which were similar to those of Knudsen and in some cases a repetition of the latter. Knudsen had investigated the reflection of mercury molecules at a glass surface cooled by liquid air, and details of his experiments and apparatus are given. The author now describes experiments using gold as the reflecting surface. Details of the method and apparatus are given. It is concluded that a perfectly clean gold surface would not reflect at all at —120° C. A remarkable difference is found between the reflecting powers of gold and iron; at —100° C. gold reflects at least 5–10 times less than iron and glass, and reasons are put forward to explain this remarkable difference. H. H. Ho.

837. *Rôle of the Gravitational Field in the Structure of Material Particles.* **A. Einstein.** (Preuss. Akad. Wiss. Berlin, Ber. No. 20. pp. 349–356, 1919.) —Neither the Newtonian nor the relativity theory of gravitation has hitherto contributed substantially to the elucidation of the constitution of matter, and the present paper attempts to show that support is forthcoming for the view that the components of the atoms, which are electrical conceptions, are held together by gravitational forces. Section I deals with the defects of current hypotheses. Mie, for example, has conducted an elaborate investigation to uphold a theory which accounts for the electron on an electrical equilibrium basis. This theory, which has obtained considerable acceptance, depends essentially on the introduction into the energy tensor of the Maxwell-Lorentz theory of the electromagnetic field, of terms dependent on the components of the electrodynamic potential in addition to the energy terms already present. The new terms, which have no appreciable effect *in vacuo*, act in the interior of the electrical particle elements so that equilibrium is brought about between the electrical impact forces. The physical results, however, of this theory are unsatisfactory, owing to the multiplicity of the possibilities and the complexity of the terms introduced. The present author now demonstrates the possibility of a theoretical construction of matter based on the gravitational and electromagnetic fields alone, and without the introduction of hypothetical expressions as in Mie's theory. Section 2 of the paper deals with the scalar free field equations, and section 3 with the cosmological problem. It is shown that of material energy, three-fourths is due to the electromagnetic field and one-fourth to the gravitational field. Section 4 contains a short summary of the results obtained.

H. H. Ho.

838. *The Formation and Persistence of Fog.* **A. Trillat** and **M. Fouassier.** (Comptes Rendus, 168. pp. 570–572, March 17, 1919.)—The paper describes an apparatus for enabling measurements to be made of the ease of formation and the persistence of fog in any given sample of air.

The apparatus consists of a closed glass vessel of 10 litres' capacity, provided with an exhausting pump and a mercury manometer; also with a device for noting when fog of a standard opacity has been produced. The air to be tested having been introduced into the vessel, the pressure inside is reduced by means of the pump, until the standard fog is produced. The reading of the manometer then gives a measure of the difficulty of production of fog. Similarly the apparatus can be used to obtain particulars of the persistence of fog. It is found that dust particles, which are always present in ordinary air, are of different kinds. Those particles which are insoluble in water are ineffective in producing fog, while soluble dust particles allow fog to be produced upon them with the application of only a slight reduction of pressure.

R. C.

839. *Motion of the Air in the Lowest Layers of the Atmosphere.* **G. Hellmann.** (Preuss. Akad. Wiss. Berlin, Ber. 22. pp. 404–416, 1919.)—The ground wind is investigated by measurements of wind velocity at five different heights between 5 and 200 cm. above unobstructed ground near Berlin, and it is found that in this lowest layer the mean wind velocities are proportional to the *fourth* roots of the corresponding heights.

The previous work of the author for heights varying from 200 cm. (2 m.) to 258 m. above the ground gave rise to a similar result, in which, however, the velocities were proportional to the *fifth* roots of the corresponding heights. R. C.

840. *Ocean Temperatures in Long-range Forecasting.* **C. F. Brooks.** (Monthly Weather Rev. 46. pp. 510–512, Nov., 1918. Paper read before the Assoc. of Am. Geographers, Dec., 1918.)—If it is possible to forecast the distribution of surface water temperature over the oceans a few weeks in advance it may prove possible to forecast the general paths which will be followed by cyclones and anticyclones and thus to make long-range forecasts of the weather. The author discusses how changes of water temperature are brought about and how cool or warm masses of water may travel slowly for months in the great ocean currents like the Gulf Stream or Labrador current. Owing to the slowness of travel, there are possibilities of forecasting ocean temperature a considerable period in advance. The following is an example of the sequence of events. A body of unusually warm water passed through the Straits of Florida in Jan., 1916, and travelled later to the Western Atlantic. In Feb., March, and April of that year many cyclones approaching the Atlantic Coast of the United States passed eastwards and became intense over the warm water. The northerly winds in their rear gave unusual cold and snow in the Middle and North Atlantic States. It is pointed out that the problem is complicated by the interrelation between cyclones and ocean temperature; warm water may cause a cyclone to increase in intensity and the resulting strong winds then bring in water from different regions and modify the ocean temperature-distribution. The bearing of the results of North Atlantic studies on similar North Pacific problems is considered.

J. S. Di.

841. *The Dustfalls of March,* 1918. **A. N. Winchell** and **E. R. Miller.** (Monthly Weather Rev. 46. pp. 502–506, Nov., 1918.)—Unusually heavy dustfalls occurred in March, 1918, in the Central and Eastern parts of the United States. The dust was well sorted and very fine, indicating that it had travelled a long distance in the atmosphere. There were good reasons

for thinking that it had been carried in the upper air currents and not in the surface winds. Certain well-marked cyclonic storms passed across the States during the period of the dustfalls. From the computed movement of the upper wind currents trajectories of the air which carried the dust are worked out for the days preceding the fall. The regions of the dustfall and the probable place of origin are indicated on maps. The quantity of dust as measured at Madison, Wis., on Mar. 9, amounted to 4·8 gm. per m.^{2}, or 18·5 tons per square mile. The snow in which the dust fell was of a light yellowish colour. The dust consisted chiefly of minerals with some plant tissue; nearly 80 % lay between 0·005 and 0·025 mm. diameter.
J. S. Di.

842. *Hourly Duration of Precipitation in Philadelphia.* **G. W. Mindling.** (Monthly Weather Rev. 46. pp. 517–520, Nov., 1918.)—For some purposes a knowledge of the rainfall duration, as distinguished from rainfall intensity, at different times of day, is of economic importance. In the present paper the duration is worked out from ten years' records at Philadelphia. Consideration of previous work on the same subject shows that in such an inquiry each station must be treated individually, the results for one place not being applicable to another where the local conditions may be different. Each month has been treated separately in the present work. The curves setting out the results show great irregularity from month to month. The durations range from 5·6 hours of rain per month between 10 and 11 p.m. in Jan. to 1·2 hours per month between 9 and 10 a.m. in July. J. S. Di.

843. *Smoke as an Indicator of Gustiness and Convection.* **P. W. Etkes** and **C. F. Brooks.** (Monthly Weather Rev. 46. pp. 459–460, Oct., 1918.)—Describes the different forms which the smoke trail from a tall factory chimney may take and the different types of wind structure associated therewith. J. S. Di.

844. *Distribution of Rainfall over Germany.* **G. Hellmann.** (Preuss. Akad. Wiss. Berlin, Ber. 22. pp. 417–432, 1919.)—The construction of a new rainfall chart of Germany based upon simultaneous observations extending over twenty years at about 3700 places reveals the wettest and driest districts, as well as those regions over which winter rain is pronounced. The limits of mean annual rainfall shown on the map are 2600 mm. and 380 mm. While as a rule summer is the season which gives most rain in Germany, the winter fall is greater than the summer fall in the higher districts of the West German hill-country; but in the Alps winter rains are unimportant. R. C.

845. *Forecasting Line-squalls in West Africa.* **H. Hubert.** (Comptes Rendus, 168. pp. 567–570, March 17, 1919.)—From observations made in Senegal in winter it can be shown that line-squalls, similar to those experienced in NW. Europe, occur in that region also. The mean direction of propagation is, however, from east to west, instead of from west to east, which is the mean direction of propagation of the line-squalls of our latitudes. The mean velocity of propagation is 60 km. per hour, the extremes being 44 and 72 km. per hour. The direction of the line along which the disturbance is found at any time is generally North–South. The length of the line may exceed 100 km., and the passage of a squall has been traced for hundreds of kilometres. Nothing is said as to changes of wind and weather accompanying these line-squalls. Further observations are needed in districts adjacent to Senegal in order to investigate these squalls more precisely, but already sufficient stations exist in Senegal to permit of a warning of the approach of a squall to be issued a few hours (up to 6 or 8) in advance of the event. R. C.

846. *Atmospheric Periodicities.* **J. Lévine.** (Comptes Rendus, 168. pp. 566–567, March 17, 1919. Extract.)—A curve is drawn showing serial values of the lowest reading of the barometer at Paris for each year from 1700 to 1918, from which it appears that there is a periodicity in this quantity of about 96 years—the curve for 1700 to 1821 being very similar to that for 1796 to 1916. R. C.

847. *Volcanic Explosions.* I. *Explosive Eruptions and their Phases.* **V. Sabatini.** (Accad. Lincei, Atti, 27. ii. pp. 360–364, 1918.)—Water-vapour alone is capable of explaining the mechanical effects produced in volcanoes and the projections from the latter, and there is evidence indicating that water-vapour constitutes almost the whole of the gaseous products of volcanic smoke columns; the source of this vapour is not yet established. At the high temperatures prevailing in the depths of volcanoes, the water-vapour is easily decomposable by various elements, with liberation of hydrogen; actual dissociation of the water-vapour to any large extent is improbable owing to the high pressures existing.

The presence of water in the lava may be derived from water of infiltration meeting the very hot lava and being absorbed and decomposed by it, the hydrogen and any residual uncombined oxygen passing up into the crater and there meeting the atmospheric oxygen entering through the fissures, and thus giving rise to violent explosion. The law connecting pressure and temperature inside the laval mass is not known, but it is probable that the latter does not increase at the same rate as the former. At the high temperatures prevailing at great depths, the hydrogen remains gaseous, and at 2000° reaches its maximal density (co-volume).

Laboratory experiments show that the minerals formed at the highest temperatures are spinels, melting at 1900°, whilst iron chromate melts at 1850°, quartz at 1775°, and peridotes at 1780° or above; others generally melt below 1700°. Thus at 2000° or, under high pressures, at a considerably lower temperature lava cannot contain elements in the solid condition. T. H. P.

848. *Volcanic Explosions.* II. *Calculations on the Combustion of Hydrogen. Comparison with Ordinary Explosives.* **V. Sabatini.** (Accad. Lincei, Atti, 27. ii. pp. 405–407, 1918 [Compare preceding Abstract].—The energy developed in the explosion of 1/9 kg. hydrogen, with a co-volume of 1240 litres, is considered, and it is shown that 800,000 kg.-m. remain available for rupturing the cup of the crater, for enlarging the latter, and for projecting matter therefrom, a loss of one-third of the energy in heat effect and in secondary shocks being assumed. With glyceryl nitrate and explosive gelatin, the corresponding amounts of energy given per kg. are 625,000 and 652,000 kg.-m. respectively. T. H. P.

849. *Hot Volcanic Blasts.* **G. N. Cole.** (Monthly Weather Rev. 46. pp. 453–456, Oct., 1918.)—In volcanic eruptions thousands often perish instantaneously, and their bodies show burns and blisters under clothing, sometimes as frail as lace, which shows no trace of scorching by fire. Observations leave no doubt that there is a tremendous blast with a great wave of pressure due to a gigantic explosion. The outermost zones show the effects of a tornado; further inward, death by temperature effects due to adiabatic compression; and nearer the centre, effects of fire and scorching due to hot volcanic gases. With a wave travelling at such a speed, there is little chance to seek safety. W. A. R.

850. *Seismogram Analysis.* **S. Nakamura.** (Phys. Math. Soc., Japan, Proc. 1. pp. 88–94, April, 1919.)—The seismogram, recording the motion of a system of vibrating masses with a finite period of oscillation, does not give knowledge of the earth's movement without analysis. The author applies step by step to the seismogram a generalised form of the ordinary linear equation for the forced oscillation of a simple system. The functions of the displacement, velocity, and acceleration of the instrument, and its magnification, are determined experimentally. Details and examples of these determinations are given and discussed. The paper concludes with the analysis of a Gray-Milne seismogram of an earthquake (June 26, 1918), and shows that the earth movement was not sinusoidal but a succession of shocks. W. A. R.

851. *Lunar Tide in the Atmosphere.* **S. Chapman.** (Nature, 103. pp. 185–187, May 8, 1919.)—Tidal theory suggests that a lunar tide may be expected in the earth's atmosphere just as it is found in the sea. Reference is made to early attempts to determine the magnitude of such a tide. Its magnitude is very small even at the equator. At Batavia (6° S.) it may be represented by $0{\cdot}065 \sin (2t + 65^\circ)$ mm. of mercury, where t is reckoned from lunar transit at the rate of 360° per lunar day. This phase angle indicates that max. pressure occurs nearly one hour after the moon crosses the meridian. From Greenwich data the following value has been determined: $0{\cdot}0090 \sin (2t + 114^\circ)$ mm. suggesting that the amplitude varies approximately as $\cos^4\lambda$ (latitude). For Greenwich only barometrically "quiet" days were used, and the relatively large solar semi-diurnal wave was first abstracted. The mean lunar daily inequality obtained was of almost purely semi-diurnal type. J. S. Di.

852. *Notes on Sun-spots measured at Greenwich*, 1915. **E. W. Maunder.** Roy. Astron. Soc., M.N. 79. pp. 451–458, April, 1919.)—The shortening of work found necessary under war conditions has entailed the omission of details of the individual members of spot groups, but the author shows that in many cases this means losing sight of important features. Several illustrative diagrams are given. Ledgers showing the daily position of the centre of gravity of a group, give very little indication of the normal history of a group in which the leading spot advances in longitude while the rearmost spot retrogrades. This and other anomalies are discussed, and suggestions made as to the best plan of dealing economically with the difficulty. W. W. B.

853. *Brightness of the Corona, June* 8, 1918. *Photoelectric Photometry.* **J. Kunz** and **J. Stebbins.** (Astrophys. J. 49. pp. 137–152, April, 1919.)—Full details are given of the arrangement of the apparatus for photoelectric photometry during the eclipse. The rubidium cell was accidentally put out of adjustment just before the eclipse, so only the potassium cell could be used,

and with that the deflection was about seven times the estimated amount. Exposures were made on the corona with sky background and also on the sky alone. The light was compared also with a standard candle, two electric lamps, and the full moon, as well as with the sky both during totality and in full sunshine. The observed light of the corona was 0·60 candle-metres, or corrected for atmospheric absorption 1·07 candle-metres. The sky light was determined from a circle of ¼° diameter 8° from the sun, and in full sunshine. This was 6100 times as bright as during totality. These figures refer to the light to which the cell was sensitive, and have not yet been corrected for the effect of prominence-light.

A discussion is included of other determinations of the brightness of the corona at previous eclipses, and it is explained that the prominences could have very little effect on the photoelectric determination, since their principal features are the H and K lines of Ca to which the K cell is nearly insensitive. W. W. B.

854. *Magnetic Polarity of Sun-spots.* **G. E. Hale, F. Ellerman, S. B. Nicholson, and A. H. Joy.** (Mt. Wilson Solar Observat., Contrib. No. 165. Astrophys. J. 49. pp. 153–178, April, 1919.)—After a preliminary account of the early investigations beginning in 1908 [see Abs. 1586 (1908)] and the classification of two kinds of vortices, namely, high-level hydrogen vortices above sun-spots, and low-level electric vortices constituting the actual spots, the authors proceed to deal with the polarity of the spots, *i.e.*, the direction in which the vortices whirl. On the earth, cyclones always move counterclockwise in the northern hemisphere and clockwise in the southern, but this is not the case with the sun, except that there is a reversal at the solar equator. The polarity is determined by observations made with a Nicol prism and a quarter-wave plate, of the n-components of a *Zeeman* triplet in its spectrum. When, however, the spot is very near the limb, special precautions are necessary, as some of the motion on the side nearest the limb will in general appear reversed by the high angle of projection. Measures of considerable precision can be made of the inclination of the lines of force in sun-spots, a majority of which are binary groups, the two main spots being of opposite polarity. Also in general a large spot with small companions has the opposite polarity to that of the companions.

Before the last sun-spot minimum the magnetic polarity of unipolar spots and of the preceding members of bipolar spots was positive in the southern and negative in the northern hemisphere of the sun, but these signs seem to have been reversed after the minimum. It will be necessary to wait until after the next minimum to test the generality of this indication of reversal.

The spots may be classified according to the polarity, and illustrated by the accompanying plates. Unipolar spots may be grouped according as the calcium flocculi precede or follow the central spot or are symmetrical about it. For bipolar spots four groups are suggested according as the main spots are equal, or whether the leader is the greater or the smaller, or whether each is accompanied by small spots of opposite polarity. Multipolar spots are not common, being about 1% of observed spots. A detailed classification is given of 970 spots observed during the years 1915 to 1917. W. W. B.

855. *Great Change in S. Tropical Region of Jupiter.* **T. E. R. Phillips.** (Roy. Astron. Soc., M.N. 79. pp. 459–461, April, 1919.)—The author calls

attention to the almost total disappearance of the S. Tropical Disturbance and Red Spot Hollow, giving a plate of the appearance at intervals from Dec. 1917 to April 1919, and an indication of increased activity in other regions of the planet. W. W. B.

856. *Motions in Space of Stars of High Radial Velocity.* **W. S. Adams and A. H. Joy.** (Mt. Wilson Solar Observat., Contrib. No. 163. Astrophys. J. 49. pp. 179–185, April, 1919.)—Thirty-seven stars of known parallax and proper motion have radial velocities exceeding 80 km. per sec. These are tabulated, allowing for the solar motion [see Abs. 646 (1918)]. It is found that the components of the velocity in the galactic plane are much greater than those normal to it, and the apices all lie nearly in one hemisphere, their galactic longitudes being between 181° and 322°. Various mean motions are deduced by projection, and a marked effect of stream motion is indicated. There is an apparent tendency to move along a line of 260° galactic longitude, nearly in the direction of the greatest star density. Eight of the stars with velocities exceeding 300 km. per sec. are omitted from the mean motion calculation, but they also show a fair degree of accordance. The apices of the fainter stars are much nearer the galactic plane, and they move more rapidly. A high proportion of the 37 stars are of type F or G, the F stars having the greatest velocities, and especially the earlier F_0-F_5 stars which have an average motion of 365 km. per sec. W. W. B.

857. *Table for Converting Photometric Estimates into Stellar Magnitudes.* **A. A. Rambaut.** (Roy. Astron. Soc., M.N. 79. pp. 439–446, April, 1919.)—Pogson's scale being logarithmic, there is an error in proportioning the steps between comparison stars if these differ much in magnitude. The present table is intended to correct for this source of error. W. W. B.

858. *Spectra of Nova Aquilæ No. 3. I. The Dark-line Spectrum.* **J. Lunt.** (Roy. Astron. Soc., M.N. 79. pp. 416–436, April, 1919.)—This paper deals only with plates taken on 1918 June 10, 11, and 12, considered by the author to mark a distinct stage in the star's history. The photographs extend from the Ti line λ3900·7 to the (probable) enhanced Fe line λ5169·1 and are in good focus between λλ4120 and 4550, not much reliance being placed on anything beyond the Cr line λ4824·3, as the region towards the red becomes rapidly out of focus. The ten plates measured have their lines fully tabulated, and two plates on June 11 and 12 with Fe comparison are reproduced. The general table includes 38 enhanced Ti-lines indicating a very high temperature. None of these lines are doubled, but four enhanced Fe-lines, as well as the Ca lines H and K and some of the H lines are doubled. Elements recognised are Ti, Fe, Cr, Se, Sr, Ca, Mg, H, He, and possibly V. The evidence points to the presence of three bodies: (1) the star proper, (2) an absorbing resisting medium, shown by the sharp H, K, and D, and (3) the gaseous products of the outburst produced by the interaction of (1) and (2). After June 15 the later spectra are attributed almost entirely to (3), and will be the subject of further communications. W. W. B.

859. *Nova Aquilæ* 1918. (Astron. Nachr. April 7, 1919. Nature, 103. p. 234, May 22, 1919. Abstract.)—Morning observations indicate that the nova is below the 6th magnitude. At Bergedorf Observatory its spectrum on April 4 consisted essentially of three bright lines in the red, yellow, and blue-green, and with the ordinary stellar eyepiece it appeared as a small reddish-yellow image covered by a bluish-green disc, the difference of focus of the colours being such that, viewed obliquely, it had the appearance of a double star with coloured components. W. W. B.

860. *Peculiarities of Nova Aquilæ* III. 1918. **E. E. Barnard.** (Astrophys. J. 49. pp. 199–202, April, 1919.)—Like Nova Persei of 1901, Nova Aquilæ showed during its decline a planetary disc. The author made careful measures of the disc from Oct. 5 to Dec. 17, the mean diam. being rather greater than 1″. He also gives colour notes. He finds that the nova appeared relatively brighter, the smaller the telescope employed, and also relatively brighter against a dark sky, so much so that he considers that simultaneous determinations might well differ by as much as a whole magnitude. This is attributed to its planetary appearance, and for that the suggestion is made that the hydrogen is responsible. The crimson image due to H_α with the 40-in. Yerkes telescope is 9 mm. outside the regular focus. W. W. B.

861. *Observations of Nova Aquilæ.* **M. Maggini.** (Soc. Spettroscop. Ital., Mem. 7. pp. 119–129, Oct.–Nov.–Dec., 1918.)—The author's observations were made on 57 nights in the period 12 June–18 Aug., in the three wave-groups 645 $\mu\mu$, 558 $\mu\mu$, and 412 $\mu\mu$. The photometer used was that described in Abs. 662 (1918). A table and also curves are given showing the variation of the light for each of the three wave-groups. On June 12, when the star was white like α Lyræ, the brightness in 412 $\mu\mu$ surpassed that in the other two rays; by June 18, although the brightness was below mag. 2 the light was considerably less red. Further curves are given showing the variation in spectral type. These reveal the tendency to revert to the former spectral type still more clearly. Thus on June 12, 18, 24 and 30, that is at intervals of six days, there is a reversion to the spectrum types F and A. A third set of curves shows the variation in effective temperature of the star over the observation period, calculated from thermodynamic considerations. For June 12 the temperature at the three wave-lengths was 14,500°, 13,500°, 17,500° respectively. It is concluded: (1) that the spectral energy distribution of the nova has changed from one end of the spectrum to the other, *i.e.*, the nova does not radiate like a black body; (2) except for the rapid variations of some days in June, the differences between the three temperatures are continually increasing while the light of the nova is diminishing. Thus the law of radiation followed becomes still less like that of a black body. L. H. W.

862. *Atmospheric Extinction for Stars of Different Spectral Types.* **A. Bemporad.** (Soc. Spettroscop. Ital., Mem. 7. pp. 94–99, July–Aug.–Sept., 1918.)—In place of the usual method of wedge-photometer comparison of stellar magnitudes the author employs an absolute method in which the magnitude is determined from an equation of the type $M = x - cW$, where M is the magnitude, c the wedge constant, W the wedge reading (in mm.), and x the limiting magnitude corresponding to "zero" wedge reading. Since c may be regarded as constant this can be written $M = x - W$. For a given wedge and given spectral type, $M + W =$ a const. For stars of different colours different values of $M + W$ are obtained; *i.e.*, lower values for yellow than for white stars. Since the value of x depends on the atmospheric transparency, the two stars to be compared should be near to one another and at the same altitude above the horizon. In actual practice the equation $M + W = x - yE(z)$ is used, where $E(z)$ is the extinction corresponding to the zenith distance of

the star, and y is the ratio of the effective atmospheric extinction to the extinction E(z). Examples are given showing that the method gives values for x which are larger (magnitudes smaller) in the case of stars of types F, G, K than for stars of types A and B. The y-values are also larger. L. H. W.

863. *Origin of Binary Systems.* **J. H. Jeans.** (Roy. Astron. Soc., M.N. 79. pp. 408-416, April, 1919.)—Following out a previous suggestion [see Abs. 258 (1919)] that the older binaries might have reached a final state of equipartition of energy after gravitational buffeting from other stars, the author proposes to test this by comparing the distribution of periods and eccentricities in the ideal steady state with that observed in actual binaries. He finds that in the ideal state there would be no correlation between period and eccentricity, that all values of the square of the eccentricity would be equally likely, and that the periods would conform to a particular law of distribution. On the other hand, Aitken has found strong correlation between period and eccentricity, and not even an approximate agreement with the theoretical laws for either period or eccentricity. These results come from the examination of 119 spectroscopic and 87 visual binaries. B-type binaries the author proposes to exclude, as their periods are nearly all short and their eccentricities small, and he ascribes them to comparatively recent fission. He then finds that the periods in the final state crowd into the range of small values, so that for every star with a period between 80 and 1000 years there ought to be about 17 with periods between 80 and 81 days, and 820,000,000 with periods between 10 and 11 days. There should also, he finds, be an infinite number with periods greater than 1000 years. But there is a critical value for the period about 1 year, shorter periods tending to lengthen and longer ones to shorten.

The binaries known fall into two classes, with periods less than a year and greater than a year respectively, almost coinciding with spectroscopic and visual binaries. These, however, he thinks are not a fair sample, as, for instance, the stars with periods of 1 year would be very difficult to discover. Taking our nearest neighbours so far known as a fair sample, he finds that of Eddington's 19 stars, nine are certainly binary, and of these the periods of five are known. All five have periods between 80 and 1000 years, so that his theory would indicate the existence within the same region, *i.e.* within 5 parsecs of the sun, of thousands of stars with periods between 80 days and 80 years, and millions with shorter periods. This result he rejects as impossible, and is inclined to reject his previous conclusion that all binaries originated by fission, and to prefer in many cases independent neighbouring condensations, but he gives no definite conclusion. W. W. B.

864. *Spectrum of Comet Mellish* (1915*a*). **A. E. Glancy.** (Astrophys. J. 49. pp. 196-199, April, 1919.)—Two series of plates were taken at the Argentine National Observatory at Cordoba, with different instruments and dispersions. The spectrum closely resembles that of Comet Brooks (1911*c*), and details are given of variations in intensity which do not all agree with visual observations. The limiting dates were 1915 June 5 to Aug. 19, perihelion being July 17. W. W. B.

865. *Orbits of Three Spectroscopic Binaries.* **W. S. Adams** and **A. H. Joy.** (Mt. Wilson Solar Observat., Contrib. No. 164. Astrophys. J. 49. pp. 186-195, April, 1919.)—The three stars discussed are: (1) The brighter component of Σ 5 (80 Arietis).—Period 9·851 days, and projected semi-axis major about three million km.

(2) W Ursæ Majoris.—This appears to be an eclipsing binary, with period of 8 hours, and the masses, etc., of the components are computed. Each appears to have a radius about three-fourths of that of the sun, and the densities are 2·8 times and 1·9 times that of the sun, the highest known among the stars. The surfaces appear to be four times as bright as that of the sun.

(3) Z Herculis.—This also is an Algol variable, but the eclipses are not total. The period being almost exactly 4 days the photometric observations cannot all be taken at one season. Both components have masses greater than that of the sun. The larger star is the fainter. W. W. B.

866. *Photometric Observations of Nova Aquilæ.* **E. Paci.** (Soc. Spettroscop. Ital., Mem. 8. pp. 17–28, Jan.–Feb.–March, 1919.)—Tables of results of observations of apparent magnitude made with a wedge photometer in the period June 20–Dec. 14. L. H. W.

867. *Light-Curve and Elements of the Variable TV Cassiopeiæ.* **O. Lazzarino.** (Soc. Spettroscop. Ital., Mem. 7. pp. 89–93, July–Aug.–Sept., 1918.)—From the light-curve the author deduces the more probable value, 8·2 mag. at minimum. The normal light of the star gives the value 7·3 or 7·2 mag., according as this is taken from the ascending or descending branch of the curve. The max. rate of variation is 0·21 mag. per ¼ hour, in the region + 0h. 30m. and + 1h. 0m. (where 0 is the time of minimum). The value for the period is less certain; it is given as 1·812589 days. L. H. W.

868. *The Spectroscopic Binary H.R.* 8170. **J. S. Plaskett.** (Roy. Astron. Soc. Canada, J. 13. pp. 174–178, April, 1919.)—This star (1900: R.A. 21 h. 17·2m., Decl. + 39° 55′, Phot. Mag. 6·96, Type F8) is the first spectroscopic binary discovered, and the elements of its orbit determined, at Victoria. Fifteen plates were taken during four months, covering nearly 40 cycles, and the results are tabulated, the final elements being $P = 3{\cdot}2434$ days, $e = {\cdot}022$, $K = 62{\cdot}23$, $\gamma = 1{\cdot}44$, $\omega = 357{\cdot}^\circ 5$, $T =$ J.D. 2,421,801·5, etc. The author points out the excellent quality of the work obtainable from the telescope and spectrograph at Victoria. H. F. H.

869. *Third List of Spectroscopic Binaries.* **J. S. Plaskett.** (Roy. Astron. Soc. Canada, J. 13. pp. 191–198, April, 1919.)—Particulars of 20 additional binaries are tabulated in precisely the same manner as in the second list [see Abs. 704 (1919)], making 50 tabulated to date. Two of the stars now dealt with—Boss 282 and 283—form part of a system of 5 stars; two more, —Boss 1336–7—are separated by 9·5″ and are only approaching at about 0·5″ per century, thus being probably physically connected, their types, magnitudes, and mean velocities being similar. H. F. H.

870. *ν Geminorum, a Long-period Binary.* **W. E. Harper.** (Roy. Astron. Soc. Canada, J. 13. pp. 179–182, April, 1919.)—This star (1900: $a = 6$h. 23·8m.; $\delta = +20° 17'$, Mag. 4·06; Type B5) was announced by Lee as a spectroscopic binary from 5 plates in 1901–9, but the author has now measured 33 plates, and gives the provisional elements obtained ($P = 9{\cdot}6$ years; $e = 0{\cdot}20$; $\omega = 285°$; $\gamma = +38{\cdot}45$; $K = 30$ km., etc.). There appears to be a short-period oscillation in the velocities, but no satisfactory period has been obtained. Minor variations, due possibly to the third component, complicate the results. H. F. H.

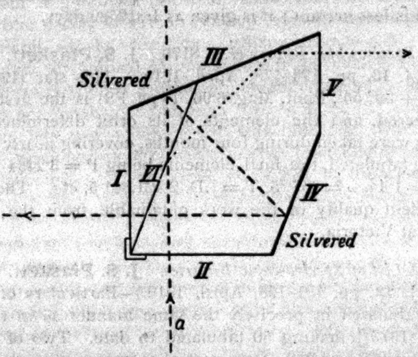
LIGHT.

871. *Stereoautograph.* **I. H. Lüscher.** (Zeits. Instrumentenk. 39. pp. 2–19, Jan., 55–67, Feb., and pp. 83–91, March, 1919.)—This paper gives a full description of the improvements and use of the 1914 Model stereoautograph for the mechanical evaluation of the stereophotograms. The theory of the instrument is also given. The paper does not admit of brief abstract. A. W.

872. *The 72-in. Telescope of the Dominion Observatory, Canada.* **J. S. Plaskett.** (Nature, 103. pp. 105–108, April 10, 1919.)—[See also Abs. 167 (1919).]

873. *New Double Prism.* **A. Grünert Schellens.** (Zeits. f. Vermess. 47. pp. 128 and 225, 1918. Zeits. Instrumentenk. 39. pp. 132 and 133, April, 1919.)—The shape of the double prism is shown in the diagram.

Surfaces I and II are at right angles to one another, and V is parallel to I.



Surfaces III and IV, which are silvered, include an angle of 45°. The surface of separation of the two parts of the prism (VI) is cemented in the upper half, but there is no cement in the lower half. The ray paths are consequently as shown. A. W.

874. *Absorption of Turbid Media; Influence of Size and Number of Particles.* **C. Chéneveau** and **R. Audubert.** (Comptes Rendus, 168. pp. 553–555, March 17, 1919.)—From the work of Rayleigh a formula for the absorption by turbid media is here derived which gives the absorption in terms of the size of the particles and their number. E. H. B.

875. *Absorption of Turbid Media; Application to Dosage of Suspensions.* **C. Chéneveau** and **R. Audubert.** (Comptes Rendus, 168. pp. 684–687, March 31, 1919.)—The author showed previously that the absorption of a turbid medium (with large particles) could be expressed in two ways, of which one is a transformation of Rayleigh's formula, namely: $1 - I/I_0 = 1 - e^{-KNd/\lambda^n}$. The variation of the absorption for different radiations is shown very clearly by this form, and allows a simple determination of *n*, the index of the wavelength. In fact, *n* can be expressed as a function of N and *d* (number and diam. of the grains). Thus, in some cases it was found that $n = A + B \log N$. This applies to particles from 1μ to 12μ. [See preceding Abs.] (*Ibid.* pp. 766–768, April 14, 1919.)—An application of the above quantitative relations which allows of a determination of N and *d* and so of the amount of the material of the particles per litre. E. H. B.

876. *Light-Absorption of Aluminium Oxide.* **H. Miething.** (Deutsch. Phys. Gesell., Verh. 18. pp. 201–212, April 30, 1916.)—Describes experiments on the coefficient of absorption, for light of different colours, of Al_2O_3 at various temperatures. The coefficient varies with the colour, but not with the temperature. For oxides containing an appreciable quantity of iron, however, the coefficient changes with temperature as well as with the colour of the light. J. W. T. W.

877. *Spirit Levels.* **E. O. Henrici.** (Optical Soc., Trans. 20. pp. 45–57, Dec., 1918.)—A description of the requirements which should be fulfilled by levels used for the most accurate work, including a discussion of the effects of temperature-change, quality, degree of polish and cleanliness of the glass, and the nature, quality, and purity of the liquid. An optical arrangement for increasing the accuracy of reading the bubble position is also described. The paper concludes with a bibliography of the subject. In the *discussion*, **E. H. Rayner** considered in detail the various factors enumerated above, and said that the mobility was the most important property of the liquid used, while other factors requiring attention were an even temperature of the whole level, and the capacity of the liquid for producing a well-defined bubble. J. W. T. W.

878. *Errors of Measurement with Range-finders.* **H. Schulz.** (Zeits. Instrumentenk. 39. pp. 91–96, March, and pp. 124–132, April, 1919.)—Gives a discussion of the errors of measurements made with range-finders, special reference being made to the physiological limitations of the human eye, to the form of the object dealt with, and to various instrument characteristics. A. W.

879. *Spherical Aberrations of a Thick Lens.* **T. Y. Baker** and **L. N. G. Filon.*** (Optical Soc., Trans. 20. pp. 67–92, Dec., 1918.)—Proposes an empirical formula of the form $\alpha t^2/\{1 + (\beta' - \beta/\alpha)t^2\}$ for expressing the spherical aberration of a thick lens, and shows by computation of given lenses, that the results generally approximate very closely to the values given by the formula. For a case in which the first-order aberration is zero, but higher orders are not zero, it is proposed to investigate a formula of the type $(At^2 + Et^4)/(1 + Bt^2)$, *t* being the tangent of the *final* inclination of the ray considered. J. W. T. W.

880. *Decentred Lens Systems.* **A. E. Conrady.** (Roy. Astron. Soc., M.N. 79. pp. 384–390, March, 1919.)—A discussion of the effect of small axial displacements of the different elements of a lens system, showing that this effect may be of importance in the case of such instruments as that used for the Franklin-Adams charts, where the distortion may amount to whole seconds of arc. A simple method is described, by means of which the amount of the effect may be determined and allowed for in practice.

J. W. T. W.

881. *Spherical Aberrations of a Thin Lens.* **T. Y. Baker** and **L. N. G. Filon.** (Optical Soc., Trans. 20. pp. 58–66, Dec., 1918.)—Determines the form of the first- and second-order caustics of a thin lens. J. W. T. W.

882. *Diffraction Figures due to an Elliptic Aperture.* **C. V. Raman.** (Phys. Rev. 13. pp. 259–260, April, 1919.)—Photographs are shown of the diffraction pattern obtained near the focus of a converging pencil of rays from an elliptic aperture. The transition from the Fresnel to the Fraunhofer class of diffraction figure is traced and attention drawn to the geometric law to which the pattern conforms—namely, that the brightest part of the diffraction pattern outside the elliptic cross-section of the beam lies within the geometric evolute of this cross-section and is bounded by it.

E. H. B.

883. *A Property of the Photographic Plate analogous to the Purkinje-effect.* **J. A. Parkhurst.** (Astrophys. J. 49. pp. 202–206, April, 1919.)—The Purkinje-effect in reference to visual photometry may be described thus: If two sources of light, one white, the other red, appear equal at a certain intensity, they will not remain equal if the intensity of both sources be changed in the same ratio. For example, if the intensity of each is doubled, the red will appear brighter than the white light; or, if the intensities are halved, the red will appear fainter than the white. This is equivalent to saying that the "contrast" appears greater in the red than in the white light. It also follows that as the intensities increase, the max. sensitiveness of the eye shifts towards the red; or, if intensities decrease, the maximum shifts toward the blue. Numerous investigators have tested the photographic plate for a corresponding effect. Abney finds that "the least steep gradation is that given by the monochromatic light to which the simple silver salt experimented with is most sensitive, and that the gradation becomes steeper as the wave-lengths of light employed depart in either direction in the spectrum from this point, the steepest gradation being given by the extreme red. It is important to note that this change of gradation is in the same direction as occurs in visual comparisons. The implied shift in the wave-length of max. sensitiveness on the plate has been independently confirmed by the work of a number of observers on the effective wave-length of light from stars of different colours. It would thus appear that this property of the photographic plate is sufficiently confirmed in a qualitative way by these entirely independent investigations. It is the purpose of this paper to find provisional, or at least limiting, values for the amount of error which might arise from this property in photographic stellar photometry. The conclusion arrived at is that the amount of error introduced by neglecting this property analogous to the Purkinje phenomenon, on Seed 27 plates, and with extra-focal images, is of the same order as the accidental errors. A. E. G.

884. *Unit of Light.* **E. Warburg.** (Deutsch. Phys. Gesell., Verh. 19. pp. 3–10, Jan. 30, 1917. From the Physikal.-Techn. Reichsanstalt.)—Considers the advantages of a given area of a "black-body" cavity at a given temperature as a unit of light. J. W. T. W.

885. *Selenium Photometry.* **F. Köhler.** (Elekt. Zeits. 40. pp. 104–106, March 6, 1919. From the Wiss. Laborat. d. Radiologie-Gesell., Berlin).—Investigates the period of rest necessary in order that selenium cells (of the "Radiologie" type) shall show consistent values of conductivity on exposure to various intensities of illumination for one minute each. These periods of rest are shown to vary from 5 mins. for 14 lux to 10 mins. for 45 lux and 14 mins. for 200 lux. The conductivity in the light then remains constant within about 2 %. The voltage used was 8, and the current through the cells was about 0·1 milliamp. The conductivities are given in arbitrary units. The author advocates the use of several different Se cells for photometry, so as to allow of the necessary rest periods. E. E. F.

886. *Aerial Photographic Mapping.* **M. A. Kinney.** (Flying, 8. p. 250, April, 1919. Frank. Inst., J. 187. p. 579, May, 1919. Abstract.)—Aerial photography has opened an entirely new field of endeavour. Whereas the ordinary map surveyor would have to make his calculations on a yearly basis, the aerial photographic surveyor estimates from the standpoint of hours. By aerial photography a map just as accurate as that produced by the surveyor, and far more comprehensive, can be made available within 48 hours after the flight to take the exposures. A number of automatic and semi-automatic cameras have been produced, ranging in size from the 4 × 5 camera with 8·5 in. focal length to the enormous cameras of 50-in. focal length and 8 × 10 plates. One of the most ingenious of these cameras is the Eastman K–1. This camera is entirely automatic in its action. It is set on the floor of the fuselage and operated by a controlled wind turbine. Roll film is used, and 100 pictures 8 in. by 10 in. in size can be made without reloading. The use of film of such large size presented a problem, because of vibration. The difficulty is overcome by providing a vacuum suction which accurately holds the film in the recording plane without liability of static. This K–1 camera can in one continuous trip at an altitude of 10,000 ft. take sufficient exposures to cover an area of some 200 sq. miles. It records approximately 2 sq. miles of area at each exposure. The photographs gathered on a mapping trip can be pieced together in an accurate mosaic by a method of triangulation. The photographic map, on completion, may be traced and interpreted into the usual form of topographical map. A. E. G.

887. *Photographic Paper for Hard X-rays.* (German Pat. 308,645. Elektrot. u. Maschinenbau, 37. p. 124, March 23, 1919. Abstract.)—Photographic paper such as is used in determining doses is found not to be sensitive to very hard X-rays. J. Bräuninger has found that it can be made sensitive. The hard rays are first passed through a layer of metal in which secondary β-rays are generated that are so soft as to be absorbed by the paper, and there the necessary chemical action for the measurement is called forth. The paper can be eventually enclosed in metal foil, which also serves as a light-screen to it. A. E. G.

888. *Arc-spectrum of Vanadium.* **W. Ludwig.** (Zeits. Wiss. Photochem. 16. pp. 157–185, Jan., 1917.)—One of a series of papers on measurements to three decimal places in international units, made at Bonn under Kayser with a Rowland concave grating of 6·34 m. radius, 20,000 lines to the inch, 110,000 lines altogether, the dispersion being such that 1 Å.U. corresponds to about 1 mm. The arc electrodes are of the respective metal, or of either copper or

carbon; a hole is made in the lower (positive) electrode to take the substance, or the carbon is impregnated with a salt of the metal. For the photography Schleussner gelatin-emulsion plates are used. In the case of vanadium measurements were made particularly in the short-wave portion of the spectrum, λ2207 to 4646; the tabulated lines (intensity and wave-length) are compared with those of Exner and Haschek, Rowland, Harrison, and also Kilby; the author does not agree with the latter. Very steady arcs of 0·5 amp. at 220 volts were obtained with copper electrodes containing vanadic acid; carbon electrodes impregnated with divanadyl tetrachloride were also used. H. B.

889. *Arc-spectrum of Tungsten.* **M[aria] Belke.** (Zeits. Wiss. Photochem. 17. pp. 132–142, Dec., 1917, and pp. 145–168, Feb., 1918.)—[Compare Ludwig, preceding Abs.]. The range of the measurements extends from λ2249 to λ6984, the comparison data being those of Exner and Haschek. There is again no confirmation of Paulson's constant frequency-differences. H. B.

890. *Arc-spectrum of Tantalum.* **H[edwig] Josewski.** (Zeits. Wiss. Photochem. 17. pp. 79–96, Oct., 1917.)—[As to general features compare Ludwig, Abs. 888 (1919)]. A lower carbon electrode with cavity was used; copper electrodes were substituted when working near cyanogen bands. The exposure lasted seven hours sometimes. The comparison data are those of Exner and Haschek, who measured more lines than the author. The occurrence of pairs of lines with a constant frequency-difference, suggested by E. Paulson (1915) is not confirmed. H. B.

891. *Arc-spectrum of Molybdenum.* **M[artha] Puhlmann.** (Zeits. Wiss. Photochem. 17. pp. 97–131, Dec., 1917.)—[Compare Ludwig and Josewski; preceding Abs.] An Abney arrangement with movable slit was used, only the central portion of the 10-mm. arc of 5 or 6 amps. at 150 volts being utilised. As a rule powdered molybdenum was placed in the cavity of the lower (positive) electrode, rolled copper, 5 mm. diam., though those arcs did not burn well; the exposure took from 5 mins. to 2½ hours. The tables refer to Exner and Haschek and also to Weigand; Paulson's constant frequency-differences, based on the measurements of Exner and Haschek (to two decimals only, not to three) are not confirmed. H. B.

892. *Relative Intensity of Spectra in Gas Mixtures.* **J. Franck** and **G. Hertz.** (Deutsch. Phys. Gesell., Verh. 18. pp. 213–220, April 30, 1916.)—This paper gives a discussion of the facts known up to the present concerning the relative intensity of the spectra occurring in the glow discharge in gas mixtures, the discussion being based on the laws of energy exchange between slow-moving electrons and gas molecules. It is shown that in the case of a mixture of gases of small electron affinity, the gas having the smaller ionisation potential must always emit its spectrum to a greater degree than the other gas. This conclusion has been verified from experimental results previously published. [See Abs. 1319, 1853 (1913), 310 and 1583 (1914).] A. W.

893. *Theory of Band Spectra.* **T. Heurlinger.** (Phys. Zeits. 20. pp. 188–190, April 15, 1919.)—According to a hypothesis of Schwarzschild, band spectra are emitted or absorbed when the electron system of a molecule passes from one stationary condition to another, and at the same time the

quantum numbers corresponding to the rotary movement of the molecules are altered. The present paper gives a theoretical treatment of one consequence of this hypothesis. A. W.

894. *Intensity of Spectrum Lines from a Grating.* **V. Polara.** (Soc. Spettroscop. Ital., Mem. 7. pp. 130–136, Oct., Nov., Dec., 1918.)—Discusses the theory of intensity of the lines produced by a diffraction grating of given dimensions, and the distribution of the principal maxima and the secondary maxima and minima. J. W. T. W.

895. *Arc-spectrum of Gadolinium.* **J. M. Eder.** (Chem. Zentralbl. ii. p. 362, 1917. From the Photochem. Lab. d. Graph. Versuchsanstalt, Wien, pp. 1467–1585, May 25, 1917.)—The material was chloride or oxide, prepared from the gadolinium obtained by Auer v. Welsbach by the fractionation of samarium and europium; the main body of the paper is taken up by the tabulated lines. In fractions of europium the author found lines indicating the presence of an unknown element. H. B.

896. *Stark-effect in Fowler's Helium Series.* **P. S. Epstein.** (Ann. d. Physik, 58. 6. pp. 553–576, April 25, 1919.)—On the basis of the quantum theory the electric separation of the first three lines of the Fowler series in ionised helium was calculated, and estimates were obtained both of the position and intensity of the components. Calculations were also made of the intensities of the lines H_α, H_β, H_γ, H_δ of the Balmer series of hydrogen. Comparison of the theoretical results with the experimental measurements of Stark affords another verification of the author's theory of the Stark-effect, as well as of Bohr's theory of intensities. [See Abs. 1930 (1918).] A. W.

897. *Decay of Fluorescence.* **O. Stern** and **M. Volmer.** (Phys. Zeits. 20. pp. 183–188, April 15, 1919.)—It is shown that it is possible, from measurements of the effect of molecular impacts on the intensity of fluorescence, and of the broadening of spectral lines by molecular impacts, to calculate the time during which the intensity of fluorescence falls to $1/e$-th of the intensity at the end of the excitation period. From such measurements, this time was found to be approximately 2×10^{-8} sec., which is in agreement with the theoretical decay time for a resonator. [See Abs. 801 (1918).] A. W.

898. *A New High-tension Transformer and its Application to the Production of Penetrating X-rays.* **F. Dessauer.** (Deutsch. Phys. Gesell., Verh. 19. pp. 155–230, Sept. 30, 1917.)—*Part I. The High-tension Transformer.* The principle of this arrangement has already been described [Abs. 65B (1919). *Part II. Application to the Production of Penetrating X-rays.* The author reviews the work of Rutherford, Duane and Hunt, and A. W. Hull, on the production of very penetrating X-rays, by means of high voltages applied to specially designed Coolidge tubes. The methods adopted by these experimenters in measuring penetrating powers are also considered and criticised. This is followed by a general outline of the author's method of producing very high voltages, using his new transformer, and by a description of a new method of measuring absorption coefficients. Experimental results show that up to the max. voltage employed, 310 kilovolts, Einstein's relation holds good. With this high voltage, X-rays of frequency $\nu = 2{\cdot}1 \times 10^{19}$ were developed, corresponding to an absorption coefficient of 0·239 in Al, and a wave-length $\lambda = 1{\cdot}42 \times 10^{-9}$ cm. **J. E. Lilienfeld.** (*Ibid.* 20. pp. 159–164, Oct. 30, 1918.)—A criticism. A. B. W.

899. *Spectroscopy of X-rays. I. The "L" Absorption Spectrum of Radium.* **M. de Broglie.** (Comptes Rendus, 168. pp. 854–855, April 28, 1919.)—The absorption spectra, for X-rays, of the elements show, in the region corresponding to the "L" emission spectrum, many absorption bands which have been measured by Wagner [Abs. 1269 (1915)] in the case of Au, Pt, and by the author (Comptes Rendus, 162. p. 596, 1916, and Journal de Physique, 1916) for W, Hg, Pb, Tl, Bi, Th, and U. In the case of six of these elements the author has measured a third band, more feeble and of shorter wave-length than the two well-known bands. This third band is important from the theoretical standpoint, since its position in the spectrum confirms Stokes' absorption law; further, it indicates that Sommerfeld's theory, which predicted only two absorption bands, should be extended.

These L absorption bands are easily observed in the case of uranium, when X-rays are passed through a solution of uranium nitrate enclosed in a thin celluloid container. In a similar manner it is comparatively simple to obtain the L absorption spectrum of radium. The author has also obtained this spectrum by placing a thin tube containing 1 mgm. of solid radium sulphate before the slit of the spectrograph. The wave-length obtained, $\lambda = 0{\cdot}659 \times 10^{-8}$ cm., assigns to Ra the atomic number $N = 88$, in good agreement with the accepted value. A. B. W.

900. *Origin of the General Radiation Spectrum of X-rays.* **D. L. Webster.** (Phys. Rev. 13. pp. 303–305, April, 1919. Abstract of paper read before the Am. Phys. Soc., March, 1919.)—Duane and Hunt [see Abs. 1419 (1915)] have produced experimental proof that the spectrum of X-rays contained no frequencies above the value whose quantum is the energy of a kathode-ray; and later [Phys. Rev. 6. p. 56, 1915], the author pointed out that this law implied that the old "pulse" theory could not hold, but that the general radiation, just as much as the characteristic radiation, must consist of long trains of continuous waves. Since then the evidence for the wave-train theory has been strengthened by a later analysis, showing that for an infinitely thin antikathode, not only the derivatives of the intensity, but the intensity itself, would be discontinuous at the limit of the spectrum.

The question which the author now considers is, What is the nature of the oscillators producing these trains of waves? If they are kathode-rays, they should show the Doppler-effect, and with it also an unsymmetrical distribution of intensity of X-rays, as though the X-rays were thrown forward by the kathode-rays.

The author's views bring apparently divergent experimental observations into line with each other, and arrive at two startling conclusions. First, that electrons can radiate continuous wave-trains while in rapid forward motion; and second, that when an electron radiates all its energy, it stops first and radiates after stopping.

Several questions arising out of these conclusions are answered on the basis of the modified form of the Parson magneton [see Proc. Am. Acad. 50. 181 (1915).] A. B. W.

901. *Law of High-frequency Radiation.* **A. H. Compton.** (Phys. Rev. 13. p. 296, April, 1919. Abstract of paper read before the Am. Phys. Soc., March 1, 1919.)—Owen's law for the absorption of X-rays, that $\mu = k_1\lambda^3$, where μ is the mass-absorption coefficient, λ the wave-length, and k a constant, has been modified by Barkla to account for scattering which becomes important at very high frequencies. In his expression $\mu = k_2\lambda^3 + \sigma_0$ the mass scattering coefficient σ_0 was originally considered as a constant having the value 0·2, calculated by J. J. Thomson on the usual electron theory.

For reasons now given, the author further modifies the expression for absorption, his relation being $\mu = k_3\sqrt{(\sigma)}\lambda^3 + \sigma$, where σ is a complex function involving the radius of the electronic ring of the scattering atoms, and a function also of the wave-length.

The above relation is compared with recent experimental data as given by Hull and Rice, Williams, and Bragg and Pierce, and found to be satisfactory.
A. B. W.

902. *The Character of X-ray Spectral Series.* **W. Kossel.** (Deutsch. Phys. Gesell., Verh. 18. pp. 339–359, Sept. 30, 1916.)—A theoretical discussion based on the theories of Bohr and Sommerfeld.

The original should be consulted. A. B. W.

903. *Frequencies in the K Series of X-rays.* **W. Duane** and **T. Shimizu.** (Phys. Rev. 13. pp. 289–291, April, 1919. Abstract of paper read before the Am. Phys. Soc., March 1, 1919.)—This paper deals with the question as to whether the frequencies in the K series of X-rays are the highest frequencies characteristic of chemical elements. A number of investigators have found experimental evidence, which they interpreted as indicating the existence of radiation or absorption characteristic of a chemical element, and of higher frequency than those of its K series of X-rays.

Experiments on the X-rays emitted by an Al target, which are here described, showed that Al possesses no characteristic radiation within the range of wave-lengths examined. The range of frequencies extended from 6·34 to 43·8 times the highest frequency in the K series of aluminium. A. W.

904. *Relation between the L-series of X-ray Spectra and Atomic Weight.* **F. Kirchhof.** (Phys. Zeits. 20. pp. 211–214, May 1, 1919.)—Moseley's law brings out clearly the relation between Barkla's values for the K-series of the characteristic X-ray spectra, and the atomic numbers of the elements. In the case of the K-series, Moseley's constant is approximately 1200. Tabulating all the elements with their characteristic L frequencies, the author attempts to show, that a relation similar to Moseley's holds in this case also, the constant now being increased approximately ten-fold, namely 12,550.
A. B. W.

905. *Relation between the K-series and the L-series of X-rays.* **W. Duane** and **T. Shimizu.** (Phys. Rev. 13. pp. 306–308, April, 1919. Abstract of paper read before the Am. Phys. Soc., March, 1919.)—Measurements have been made of the absorption and emission frequencies characteristic of tungsten in both the K- and L-series, using the same calcite X-ray spectrometer throughout the investigation. The results are tabulated and analysed. It appears from the tables that the difference between the K absorption frequency and one of the L absorption frequencies equals one of the α-emission frequencies in the K-series. Further, the difference between the K absorption frequency ν and the L absorption frequency ν_1 gives the frequency of the strong α_1 line; the difference between the medium L absorption frequency ν_2 and the frequency ν gives the frequency of the medium K emission line α_2, and if the weak L absorption frequency is used, the third α-line, α_3, in the K-series is obtained.

The curve representing experiments with a tungsten target shows about 12 lines in the L-series between $\lambda = 1{\cdot}2 \times 10^{-8}$ cm. and $\lambda = 1{\cdot}50 \times 10^{-8}$ cm.

A. B. W.

906. *A further M-series in High-frequency Spectra.* **M. Siegbahn.** (Deutsch. Phys. Gesell., Verh. 18. pp. 278–282, May 30, 1916.)—For the further study of the high-frequency spectra of bismuth [Abs. 508 (1917)] and other elements of high atomic weight, the author has constructed a vacuum spectrograph which is to be described elsewhere. The paper gives particulars of wave-length measurements within the range λ 2 to 10×10^{-8} cm., obtained with the aid of a split crystal of gypsum acting as grating. The uranium lines between 3 and 4×10^{-8} cm. as well as some lines of Bi, Th, Ra, Au seem to belong to the hypothetical M-series of other investigators; only the intense lines accord with Moseley's $\sqrt{\nu}$ formula, and three uranium lines may be due to impurities. The *l*-lines mentioned in the abstract referred to probably belong to the L-series.

H. B.

907. *Complete Spectral-diagram of Crystals.* **H. Seemann.** (Phys. Zeits. 20. pp. 169–175, April 15, 1919.)—The spectral diagrams described are a combination of the Laue-Friedrich "point diagrams" with the Bragg X-ray spectrum at (at least three) different "Structure-surfaces." Excellent photographs are shown in the cases of rock-salt, sugar, and calcium platinocyanide, as illustrating different types of crystal structure. Each of the photographs appears as a symmetrical arrangement of line spectra radiating from a common centre.

A method of determining the crystal structure from the spectral diagram is described.

A. B. W.

908. *The Crystal Structure of Carborundum.* **A. W. Hull.** (Phys. Rev. 13. pp. 292–295, April, 1919. Abstract of paper read before the Am. Phys. Soc., March 1, 1919.)—Burdick and Owen [Abs. 304 (1919)] as a result of their experiments on the crystal structure of carborundum, conclude that it resembles diamond, but with half of the carbon atoms replaced by silicon, with this exception, that the carbon atoms are not in the centres of the tetrahedra formed by the Si atoms, but are displaced towards the apices of the tetrahedra, corresponding to a lack of symmetry in the carbon atom. Their conclusions are based entirely upon the relative intensities of the X-ray reflections, and their calculations are made in exactly the same manner as those of Bragg on calcite and similar crystals.

The author criticises the assumptions made by Burdick and Owen, with regard to the "scattering centre" of the atoms, and calculates the variations in intensity which might be expected from a *perfect* diamond lattice. The only assumptions made are that the electrons in the atoms are fairly stationary in the positions specified and that they scatter X-rays independently according to the classical electromagnetic theory. A table is given which shows that the agreement between calculation and experiment is as good as the data warrant, and is fully as good as in Burdick and Owen's calculations. The author concludes: "The structure of carborundum may therefore be considered, so far as our present information goes, to be *exactly* like that of diamond, in which half the carbon atoms—that is, those belonging to one of the two face-centred cubic lattices—are replaced by silicon." The disposition of the electrons around the carbon and silicon atoms is described.

A. B. W.

RADIO-ACTIVITY.

909. *Rate of Diffusion and Diameter of the Atom of Radium Emanation.* **E[lisabeth] Róna.** (Zeits. Phys. Chem. 92. pp. 213–219, April 24, 1917.)—Wallstabe found in 1903 the diffusion constant of RaEm to be 0·066 cm.^{2} per day. This rate must be too small, since the corresponding atomic radius would be at least 40×10^{-8} cm., the large radius of mannite and colloids. The author dissolves 0·5 mgm. $RaCl_2$ in water and works after Graham-Stefan at 23 to 25°; the atomic radius is calculated after Einstein-Smoluchowski, the values being reduced to 18°; the formula is $S = RT/6\pi N\eta D$, where S is the diam. of the atom, D the diffusion constant, N Avogadro's number, and η the viscosity reduced to 18°. The values obtained in water, ethyl alcohol, benzene and toluene are 1·75, 0·63, 1·30, $1{\cdot}24 \times 10^{-8}$. There is no proportionality between diffusion constant and viscosity; the diffusion constants found are, for water and toluene, 17 and 6 times greater than those of Wallstabe. H. B.

910. *Colloidal State of Radio-active Substances.* **H. Lachs.** (Kolloid Zeits. 26. pp. 165–176, Nov.–Dec., 1917. From the Radiolog. Lab., Gesell. Wiss., Warsaw.)—Discussing the general properties of solutions after Weimarn and others the author points out that some radio-active substances show, in neutral or alkaline solutions, certain colloidal properties, although the concentration of the solution is very much lower than that corresponding to saturation with the respective hydroxide. This behaviour cannot be explained by the presence of impurities. The experiments with emanation from RaA, RaB, RaC in various solvents (water, ethyl alcohol, ethyl ether, ethyl malonate, benzene) are, like those of Godlewski, made by the method of electrophoresis: an ion migrates always in the same direction, independently of the nature of the medium, whilst a colloidal particle travels in different directions in different media. Thus the aqueous solution of emanation deposits RaA at the anode, RaB at the kathode, RaC partly on the anode; in alcoholic solutions RaA goes to the kathode, the two others go to the anode. But the medium is not alone decisive for the direction of the migration; for there are always indications of the deposition of particles of opposite signs, and the relative amounts deposited vary, moreover (as with colloidal silver), with the potential applied. These experiments and the adsorption phenomena may be attributed to varying degrees of dispersity and suggest the existence of ions as well as of colloidal particles. Ordinary filter-paper retains a considerable proportion of the radio-active solution, probably in the shape of large particles containing a very large number of solvent molecules.

The conclusion drawn is that the particles of decaying emanation collect about the vapour particles, but the resulting conglomerates are not chemically bound; there is neither proper solvatation nor linkage with sol-forming ions. The particles of RaA, B, C behave in vapours as gaseous ions, but in solutions as colloids, being in the latter case apparently in physico-chemical equilibrium with the really-dissolved particles (the ions). Owing to the extreme delicacy of radio-active tests the existence of these ions can be proved under conditions which would not generally be possible in colloidal solutions. H. B.

911. *Automatic Registration of α-Particles, β-Particles, γ-Ray, and X-ray Pulses.* **A. F. Kovarik.** (Phys. Rev. 13. pp. 272–280, April, 1919.)—The method of counting individual α-particles by the scintillations they produce on a fluorescent screen is well established. α-Particles have also been counted by the method of ionisation by collision at low pressures—this method having been devised by Rutherford [Abs. 1628 (1908)]. Various modifications of Rutherford's method have been made, but the fundamental principle has remained the same. One of the modifications was the use of the Einthoven string electrometer and the photographic method of recording.

The author now describes a method of recording by a pen on a moving strip of paper. The ionisation current developed by an incoming α-particle (or other ionising particle or pulse) is magnified by a 3-valve audion amplifier. The magnified current is used to operate a very sensitive relay which, in turn, operates a local battery circuit actuating the pen on a chronograph. The sensitive relay operates on a fraction of 1 milliamp.

The above method has been applied in the cases of α-, β-, γ-, and X-rays. (Errata. *Ibid.* p. 480, June, 1919.) A. B. W.

912. *Collision of α-Particles with Light Atoms.* I–IV. **E. Rutherford.** (Phil. Mag. 37. pp. 537–587, June, 1919.)—I. *Hydrogen.* II. *Velocity of the Hydrogen Atom.* III. *Nitrogen and Oxygen Atoms.* IV. *An Anomalous Effect in Nitrogen.*

These four papers are of an extremely important nature, as they throw considerable light on the internal structure of atoms. The method of atom-analysis employed, in which α-particles are in intimate collision with the nuclei of gaseous atoms, is unique, supplying as it does, atomic data which could not be obtained by other known methods.

I. *Hydrogen.* The production of high-speed hydrogen atoms due to close collisions between α-particles and atoms of hydrogen has been studied, using the α-particles from RaC as a homogeneous source of radiation. In such close collisions, where the nuclei approach within a distance of about 3×10^{-13} cm., the number and distribution of H atoms are entirely different from those calculated on the assumption that the nuclei are to be regarded as point charges repelling each other according to the law of inverse squares. The H atoms produced by swift α-particles of range 7 cm. are shot forward mainly in the direction of the α-particles and are nearly uniform in velocity. The distribution with velocity of H atoms becomes more and more heterogeneous with decrease of velocity of the α-particles. For α-particles of range less than 4 cm. of air, the distribution and absorption of H atoms are in fair accord with the simple theory although the observed numbers are greater than those calculated on the theory.

The number of swift H atoms produced by α-particles of range 7 cm. is 30 times greater than the theoretical number. The number falls off rapidly for ranges of α-particles between 3 and 2 cm. On an average 10^5 α-particles give rise to one swift hydrogen atom in traversing 1 cm. of hydrogen. It has been calculated that all α-particles of range 7 cm. projected within a perpendicular distance $p = 2{\cdot}4 \times 10^{-13}$ cm. of the centre of the hydrogen nucleus give rise to swift H atoms. The corresponding apsidal distance is about $3{\cdot}5 \times 10^{-13}$ cm. As observed by Marsden [Abs. 1421 (1915)], hydrogen atoms are emitted by the radio-active source. The number observed is small, and it is difficult to decide whether these H atoms arise from the radio-active transformation or from occluded hydrogen in the source. An important theoretical discussion follows the statement of the above results. For this the original paper should be consulted.

II. *Velocity of the Hydrogen Atoms.* Measurements of the magnetic and electrostatic deflection of H atoms produced by the α-particles from RaC are described. The deflection in a magnetic field alone was first determined, then in a combined magnetic and electrostatic field. From the magnetic deflections it was found $mu_0/e = 3{\cdot}15 \times 10^5$, and from the electric deflection $u_0 = 3{\cdot}12 \times 10^9$; consequently $e/m = 10^4$ e.m. units. The value of e/m for the hydrogen atom in the electrolysis of water is 9570. The agreement is sufficiently close to show that the long-range scintillations produced by α-particles in hydrogen are due to hydrogen atoms carrying a unit positive charge. The agreement between the calculated and observed velocities of the H atom shows that within the margin of experimental error, the conservation of momentum and energy hold for close collisions between the atomic nuclei and that there is no sensible loss of energy due to radiation.

The relative brightness of H atoms and α-particle scintillations is discussed from the point of view of energy loss along their paths due to ionisation.

In the course of counting H scintillations, it was often noted that a number of the scintillations appeared as *instantaneous* "doubles"; *i.e.*, two points of light of about equal brightness appeared in the field of view at the same instant. This question has been systematically examined by F. Marsden, but experimental conditions were such that the effects observed were too small and uncertain to allow of drawing definite conclusions.

III. *Nitrogen and Oxygen Atoms.* From simple theoretical considerations it may be proved that all atoms of atomic weight up to oxygen should be detected beyond the range of the α-particle. Supposing that α-particles of range 7 cm. are used, the max. ranges to be expected for unit charge are for He, 28·0; Li, 19·6; Be, 15·4; B, 12·4; C, 11·2; N, 9·3; O, 7·8 cm. The case of helium has already been examined, when it was found that this atom carried a double charge, like the α-particle. It is intended later to make a systematic examination of the elements Li, Be, and B—the results so far obtained being merely preliminary. The elements nitrogen and oxygen have received very careful attention, and some startling results have been revealed. It was found that the scintillations in pure oxygen and CO_2 were of about the same brightness for corresponding ranges, and had nearly the same equivalent ranges in air as those due presumably to N atoms from the air. This is surprising, as it is to be expected that the O atoms would have considerably less range than the N atom; the calculated ranges are 7·8 and 9·3 cm. respectively. There seems to be no doubt that the effects produced by the collision of α-particles with N and O atoms are very similar to those observed in hydrogen. These observations only receive an explanation by assuming that the N and O atoms, like the H atoms, are thrown forward mainly in the direction of the α-particles.

IV. *An Anomalous Effect in Nitrogen.* In making absorption experiments with H particles in pure oxygen it was found that the number of scintillations diminished to the amount to be expected from the stopping power of the column of gas. A surprising effect was noticed, however, when dried air was introduced. Instead of diminishing, the number of scintillations was increased, and for an absorption corresponding to about 19 cm. of air the number was about twice that observed when the air was exhausted. A systematic series of observations was undertaken to account for the origin of these scintillations which were eventually proved to originate in the nitrogen. *Both as regards range and brightness of scintillations the long-range atoms from nitrogen closely resemble H atoms, and in all probability are H atoms.* This extremely important conclusion received further support by observations on the magnetic deflection of the "nitrogen" long-range atoms, again leading to the result that these atoms are H atoms.

If this be the case, *it is necessary to conclude that the nitrogen atom is disintegrated under the intense forces developed in the close collision with a swift α-particle, and that the hydrogen atom which is liberated formed a constituent part of the nitrogen nucleus.* On this view the apparently anomalous results, regarding O and N atoms, receive a simple explanation. From radio-active data it may thus be anticipated that the nitrogen nucleus consists of 3 helium nuclei, each of atomic mass 4, and either two hydrogen nuclei or one of mass 2.

The results as a whole suggest that if α-particles—or similar projectiles—of still greater energy were available for experiment, we might expect to break down the nucleus structure of many of the lighter atoms. A. B. W.

913. *Radio-activity of Rubidium.* **O. Hahn** and **M. Rothenbach.** (Phys. Zeits. 20. pp. 194–202, May 1, 1919).—The authors have compared the activities of specimens of rubidium sulphate (1) freshly prepared, (2) 11 years old, and (3) 21 years old. The activities were found to be exactly equal, within the limits of experimental error. The penetrating power of the β-rays emitted by this element has also been determined by an accurate method. The absorption coefficient in aluminium of the β-rays from UrX was found to be 463 cm.$^{-1}$, as compared with the value 510 cm.$^{-1}$ found by H. W. the β-rays of rubidium is about 58 to 60 % of the velocity of light, in good Schmidt [Abs. 471 (1909)] and that by Fajans and Göhring, 500 cm.$^{-1}$. The same method, applied in the case of rubidium, gave a value 347 cm.$^{-1}$, and for the soft β-rays from radium 312 cm.$^{-1}$. The velocity of agreement with the value $1{\cdot}85 \times 10^{10}$ cm. = 61·7 % of the velocity of light, calculated by v. Bergwitz.

A comparison of the total activity of the β-radiation of equal quantities of rubidium and uranium has also been made, the ratio being 1 : 15, with a 20 % accuracy. The ratio Ru/Th, for the β-radiation, is similarly 1 : 10. The "half-value" period of rubidium is given as 10^{11} years. Calculated in the same manner, the period for calcium is 3 to 7 times this number.

A. B. W.

HEAT.

914. *Testing Thermometers at the Reichsanstalt.* **E. Warburg.** (Deutsch. Phys. Gesell., Verh. 18. pp. 1–8, Jan. 15, 1916.)—Describes the base points on which the temperature scale of the Reichsanstalt is founded. Between the freezing-point of mercury and the boiling-point of sulphur the Pt-resistance thermometer is used. Temperatures below this range are measured with the platinum thermometer compared by Henning with the hydrogen thermometer, while for temperatures up to the melting-point of platinum a Pt and Pt-Rh thermocouple is used. J. W. T. W.

915. *The Measurement of Low Temperatures with Thermo-couples.* **T. Spooner.** (Frank. Inst., J. 187. pp. 509–511, April, 1919.)—The e.m.f.-temperature relationship of Hoskin's thermo-couple alloys was investigated down to liquid-air temperatures. Although at high temperatures the mean e.m.f. per degree is approximately constant, there is a rapid decrease in the value with decreasing temperatures. Hence the Hoskin thermo-element shows no appreciable advantage over Copper-Advance couples in this respect. E. G.

916. *On the Rapidity of Deflagrations.* **Jouguet and Crussard.** (Comptes Rendus, 168. pp. 820–822, April 22, 1919.)—Reference is first made to a formula already published for the rapidity of deflagrations regarded as plane waves [see Abs. 1172 (1918)]. This formula was obtained by assuming a monomolecular chemical reaction whose speed is zero below the deflagration temperature. In a later publication [Abs. 30B (1916)] Nusselt has given an analogous formula based on a theory which at first sight does not seem to demand any limitations to the speed of reaction. This view, however, is now shown to be only apparent, since Nusselt really replaces the above hypotheses by another relating to the heat evolved per unit of length. Under these conditions the author demonstrates the futility of extending the speed formula to reactions whose velocitiesfollow any other law. H. H. Ho.

917. *Theory of Specific Heat.* **W. Jankowski.** (Zeits. Elektrochem. 23. pp. 368–371, Dec. 1, 1917.)—A formula for the specific heat of gases and vapours is deduced on the basis of the older kinetic theory (*i.e.* without reference to the quantum theory) and without making use of the untenable conception of an equipartition of energy. The formula for the true specific heat of gases c at constant volume is $c = e_m . n(1 + i)/mni$, where e_m is the mean energy change in cals. of a molecule when the temperature is raised through 1 deg.; m the molecular weight; n the number of atoms in the molecule; and i the ratio of the change of molecular energy to that of the sum of the atomic energies, so that $i = e_m/e_a n$. That the specific heat changes with temperature is due to changes in the ratio i. The formula is tested on a large number of gases and vapours, elements and compounds; the accord for vapours may partly be due to the fact that the $k = c_p/c_v$ is calculated, not observed. As regards solids and liquids, the size of the molecule and the values of i are unknown. The formula accounts for the rule of Dulong-Petit and shows that the rule cannot be more than an approximation. Formulæ for κ are also deduced. The results are in agreement with the quantum theory; but the quantum theory goes further than the old theory in making the specific heat a function of the temperature.

H. B.

918. *Mechanical Equivalent of Heat.* **W. Jaeger** and **H. v. Steinwehr.** (Ann. d. Physik, 58. 5. pp. 487–488, April 4, 1919.)—Remarks on a previous paper on this subject by C. Sutton [see Abs. 384 (1918)]. J. W. T. W.

919. *An Extension of Trouton's Law.* **S. Arrhenius.** (Nobel Inst. Meddel. 3. 6. [9 pp.] Jan., 1915.)—In order to account for the enormous heat of the interior of the sun, which the author estimates at 3 or 4 million degrees, he extends Trouton's rule—the heat absorbed per gm.-molecule at boiling is approximately proportional to the absolute boiling-point—with the aid of van't Hoff's equilibrium constant, and calculates by extrapolation the temperatures T at which the dissociation of various substances amounts to 50 %. The ratio Q/T is then found approximately constant (roughly about 36) for the dissociation of n mols. into $(n+1)$; it is larger (55) for dissociations of n mols. into $(n+2)$, but very much smaller (less than 1) for the dissociation of hydrochloric acid, etc., when there is no change in the number of molecules (at 50,000° ?). Though all the values are very uncertain, the author considers that they support his views as to the enormous heat evolved when chemical reactions take place at the high temperatures of the sun.

H. B.

920. *Compressibility and Dilatability of Gases.* **A. Leduc.** (Ann. d. Physique [IX] 9. pp. 5–28, Jan.–Feb., 1918.)—The author has resumed experiments made 20 years ago together with Sacerdote, with improved apparatus, and has particularly investigated the monatomic gases neon and argon in order to see whether they fit into the normal series as regards corresponding states. The apparatus, a piezometer, is built up of three glass tubes; the gases were furnished by Claude, and further purified with the aid of coconut charcoal, and the determinations were made at pressures of 1, 2·8, and 5 atmos. and temperatures between 5° and 35° C. In the case of neon, the coefficient of departure from Mariotte's law is -6×10^{-6} per cm. of mercury at 17° between 1 and 5 atmos.; hence the molecular volume at 10° and 760 mm. Hg is 1·0004 (perfect gas = 1, hydrogen 1·0006); coefficient of dilatation $\beta = 3664 \times 10^{-6}$; density, 0·695 (not 0·674, Ramsay and Travers); atomic weight, 20·15 (not 20). In the case of argon: departure from Mariotte's law, $+10{\cdot}2 \times 10^{-6}$; molecular vol., 0·9990; $\beta = 3669 \times 10^{-6}$; atomic weight, 39·91. It would appear that the internal pressure varies as the square of the molecular mass, and that the internal pressure of helium should be 100 times weaker than that of argon, which is 190×10^{-5} atmo.; that is, the internal pressure of helium should only be 19×10^{-6}, practically that of a perfect gas, as K. Onnes observed.

H. B.

921. *Spectral Distribution of Energy from a Complete Radiator.* **I. G. Priest.** (Phys. Rev. 13. pp. 314–317, April, 1919. Abstract of paper read before the Am. Phys. Soc., March, 1919.)—The following new empiric formula expresses the radiant energy from a complete radiator ("black body") as a function of temperature and wave-length:

$$E_\lambda = D_1 T^5 e^{-D_2[A^{-1/2} - (\lambda T)^{-1/2}]^2}, \ldots\ldots\ldots\ldots(1)$$

where $E_\lambda \equiv$ energy of wave-length λ in the same sense as in the Planck equation. D_1 and D_2 are empiric constants. $T \equiv$ absolute temperature in degrees Kelvin. $A \equiv$ Wien displacement constant in micron degrees. $\lambda \equiv$ wave-length in microns.

From equation (1), we have for relative energy at any temperature :

$$E_{\lambda r} \equiv E_\lambda / E_m = e^{-D_2[A^{-1/2}-(\lambda T)^{-1/2}]^2} \quad \text{......................} (2)$$

where $E_m \equiv$ max. energy of wave-length λ. This formula was originally obtained as an empiric approximation to the Planck formula by graphic transformations of the latter. It was later found, for $D_2 = 4481$ and $A = 2940$, that this formula represents some of the best of Coblentz's experimental distribution data better than the Planck formula can represent them for any value of A and the corresponding value of C_2 ($C_2 = 4{\cdot}965\,A$). A table is given illustrating this. The proposed equation includes all of the following previously recognised radiation laws, each of which may be derived from it : (1) The Wien displacement law. (2) The law that the maximum energy is proportional to the fifth power of the absolute temperature. (3) The Stefan law that the total energy (integral with respect to wave-length) is proportional to T^4. But the theoretical Stefan-Boltzmann law that the definite integral with respect to wave-length between zero and infinity is proportional to T^4 cannot be derived from this equation. A revised value of the constant D_2 will be given in a later paper. (Errata. *Ibid.* p. 480, June, 1919.)

A. W.

922. *On the Rotation Entropy of a Triatomic Gas.* **K. Széll.** (Deutsch. Phys. Gesell., Verh. 20. pp. 75–80, June 30, 1918.)—The present paper contains a calculation of the rotation entropy of a triatomic gas based on the quanta methods of Planck in which every molecule is assumed to possess two equal principal moments of inertia at higher temperatures. The expression obtained is compared with one given by Sackur, which was derived from the Sackur definition of probability by the aid of the Boltzmann-Planck entropy principle. The rotation entropy for a diatomic gas at higher temperatures has already been calculated by Planck from quanta considerations coupled with Tetrode's results, and the expression obtained agrees with one derived by Tetrode and Sackur from other methods. According to Planck's conception of the quanta theory [see Abs. 347, 348 (1916)] the thermodynamic probability of each state of a mechanical or electrodynamical system, which is defined by a given number of degrees of freedom, is expressed by a definite whole number. It is also necessary that the state space of a molecule be defined in an element of known position, form, and magnitude. The dependent boundary surfaces of the element are then to be determined from the general coordinates and impulse coordinates. When these space elements are known then it is shown that the rotation entropy can easily be calculated by Planck's method.

In an analogous way Sackur has also calculated the translation entropy.

H. H. Ho.

SOUND.

923. *Singing of Sensitive Flames.* **J. Würschmidt.** (Deutsch. Phys. Gesell., Verh. 18. pp. 444–466, Dec. 30, 1916.)—Experimental and mathematical treatment of the subject. E. H. B.

924. *Acoustical Pilot Experiments.* **H. Löwy** and **E. Weyhing.** (Phys. Zeits. 20. pp. 203–207, May 1, 1919.)—Records in two full-page tables the results of a number of tests of explosions from pilot-balloons in the air. E. H. B.

925. *Interference Apparatus for Sound-waves.* **A. Tricca.** (N. Cimento, 16. pp. 63–67, July–Aug., 1918.)—In order to secure a precise opposition in phase for sounds of all wave-lengths, the author constructs a telephone receiver with a diaphragm vibrating in an air box having two openings, one on each side of the diaphragm. Sound-waves opposed in phase issue from these apertures, and can be made to produce complete silence by interference. E. E. F.

926. *Acoustic Records of Consonants.* **G. Gianfranceschi.** (N. Cimento, 16. pp. 161–172, Sept.–Oct., 1918.)—Gives some sound-curves obtained with a differential electrometer on pronouncing the consonants B, F, M, V, and R between two vowels ("ABA," etc.). Endeavours to recognise these consonants visually by the manner in which the vowel sound is obscured, interrupted, or more or less expressively restored. The attempts are not as yet very successful. E. E. F.

927. *Function of Phase-difference in Binaural Location of Pure Tones.* **R. V. L. Hartley.** (Phys. Rev. 13. pp. 373–385, June, 1919.)—Describes work which constitutes strong evidence in favour of the theory of direct perception of phase in sound-location. E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

928. *The General Fundamental Covariant Equations of the Electromagnetic Field in the Interior of Ponderable Matter from the Standpoint of the Electronic Theory.* **W. Dällenbach.** (Ann. d. Physik, 58. 6. pp. 523–548, April 25, 1919. Dissertation, Zurich.)—In Chap. I of this paper, the general covariant field equations for the interior of matter are derived from the theoretical basis of a definite electronic model of matter. The latter brings about the separation of the true and the polarisation current from the general covariant equations of the electromagnetic field in empty space by a process which completely blends the ideas of space and time. The polarisation state of matter is therein characterised by a six-dimensional vector of polarisation, which is given in a normal way as a configuration integral from the positions and velocities of the micro-charges contained in the molecules. In Chap. II the above field laws are identified for matter at rest with those of Maxwell, and it is further shown that the expression for the polarisation vector reduces to the known expressions of Lorentz's electronic theory. In Chap. III the force-density and the impulse-energy tensor are clearly derived, first for the electrostatic case and then for moving matter in a field undergoing any given variation. In Chap. IV the results of III are fully discussed. The calculated force-density is found to be also valid for anisotropic bodies with hysteresis. The impulse-energy tensor is proved to be a generalisation of that of Minkowski. It is shown that the asymmetry is not in contradiction to the equality, on the relativity theory, of impulse density and energy current. H. H. Ho.

929. *Sizes and Electric Charges in Spherules of Sulphur, Selenium, and Mercury: Reply to R. Bär.* **I[rene] Parankiewicz.** (Phys. Zeits. 20. pp. 75–78, Feb. 15, 1919.)—The author upholds her views against the criticism of her work by R. Bär, who concluded that no smaller charge than that of the accepted electron had been shown to exist. [See Abs. 188, 1263 (1918).] E. H. B.

930. *Ampère's Molecular Currents.* **W. J. de Haas.** (Deutsch. Phys. Gesell., Verh. 18. pp. 423–443, Dec. 30, 1916.)—This paper gives an account of further experiments on the reality of Ampère's molecular currents, the results of which are in satisfactory quantitative agreement with theory. It is hoped that later an exact determination of *e/m* in magnets may be made by this method. [See Abs. 1123 (1915).] E. H. B.

931. *Theory of Waves along Wires in a Conducting Medium.* **M. Abraham.** (Phys. Zeits. 20. pp. 147–149, April 1, 1919.)—A mathematical treatment of the case of two parallel wires in an unlimited conducting medium. A. W.

932. *Distribution of Electric Force between two Electrodes, one of which is covered with Radio-active Matter.* **W. J. Harrison.** (Cambridge Phil. Soc., Proc. 19. pp. 255–258, April, 1919.)—The question is treated mathematically, the calculated values of the electric force at varying distances from the electrodes being tabulated and plotted graphically. The expression for the

electric force is given as a function of the range R of the ionising α-particles, of the recombination constants and of the distance x from the electrode.

In the absence of any definite experimental results the calculation in the "general" case was not undertaken, consideration being given only to the special case where the ionisation current has reached the saturation value.

A. B. W.

933. *Diurnal Variation of the Air-Earth Current at Jersey.* **M. Dechevrens.** (Comptes Rendus, 168. pp. 572–575, March 17, 1919. Terrest. Magn. 24. pp. 33–38, March, 1919.)—Continuous records of the variations of air-earth current are obtained at Jersey, using a 55-m. tower which was formerly used for anemometry. Two large plates are buried in the ground at the foot of the tower, so that they are in electrical contact with the earth. One is connected by a conductor to the foot of the tower; from the other a wire passes through a recording galvanometer upwards to the summit of the tower. It is found that there is in general a difference in voltage shown on the galvanometer of which the diurnal variation on fine days shows a minimum during the early morning and a maximum during the afternoon. This variation corresponds very closely with the known diurnal variation of atmospheric electric potential at Jersey. On wet days the reading of the galvanometer always shows an abnormal increase. It is considered that a definite proportion of the air-earth current is conducted down the tower, and another proportion down the wire, so that the galvanometer reading is a measure of the total current. Experiments showed that the actual p.d. between the two earth plates was infinitesimal, but it is pointed out that should such a difference occur at any time owing to horizontal earth currents, the galvanometer reading would no longer give a true measure of the air-earth current.

R. C.

DISCHARGE AND OSCILLATIONS.

934. *Influence of Gases on the Photo-Electricity of Potassium.* **G. Wiedmann.** (Deutsch. Phys. Gesell., Verh. 18. pp. 333–338, Sept. 30, 1916.)—The author has previously described experiments [Abs. 1732 (1915)] which seem to prove that the photoelectric sensitivity of potassium is due to the presence of hydrogen in the metal, as is also the selective photoelectric effect at wave-length 436 $\mu\mu$. In the present experiments the effect of the presence of various gases is tested. The apparatus employed is the same as that used in the earlier work. It is found that argon and nitrogen generally cause no alteration in the photoelectric action of potassium throughout the region 436 $\mu\mu$ to 365 $\mu\mu$. Coal-gas lessens the sensitivity and oxygen increases it, but the difference of sensitivity for the three spectral regions 436 $\mu\mu$, 405 $\mu\mu$, and 365 $\mu\mu$ quickly disappears without a selective action for one or other of these lines being observed. Hydrogen has by far the greatest influence on the photo-electricity of potassium, its presence not only being necessary for the photoelectric sensitivity, but also for the selective action at wave-length 436 $\mu\mu$.

A. E. G.

935. *Spectral Photoelectric Sensitivity of Silver Sulphide.* **W. W. Coblentz** and **H. Kahler.** (Phys. Rev. 13. pp. 291–292, April, 1919. Abstract of paper read before the Am. Phys. Soc., March 1, 1919.)—Both the natural mineral acanthite and a laboratory preparation were examined. The latter material was found insensitive photo-electrically, at room temperature, but at −157° C. a sharp maximum of photoelectric sensitivity was observed for

radiations of wave-length $\lambda = 1{\cdot}05\,\mu$. At room temperatures acanthite differs from other photoelectrically sensitive substances studied in that the response becomes fatigued, and after an exposure of 2 to 3 secs. to light, the positive resistance change (galvanometer deflection) begins to be effective. For unlimited exposure, the galvanometer deflection returns to about one-fourth of its max. deflection. On removing the light stimulus, the galvanometer gives a negative deflection, which in the course of a few minutes returns to the original zero scale reading. In other words, the change in resistance of the crystal, when exposed to radiation, is first negative, then positive, the resultant change being negative and roughly one-fourth of the original change. At low temperatures, $-158°$ C., this polarisation disappears, and the response to radiation is the same as that of other substances such as selenium and molybdenite. At room temperature, acanthite has a maximum of photoelectric sensitivity for radiation of wave-length $\lambda = 1{\cdot}35\,\mu$, and also a region of high sensitivity at $0{\cdot}8$ to $1{\cdot}0\,\mu$. At $-158°$ C. the sensitivity curve is quite symmetrical, with a maximum at $1{\cdot}2\,\mu$. Mechanical working of the crystal, such as hammering it into a thin plate, has a marked effect upon this maximum, which, in one sample, occurred at $1{\cdot}18\,\mu$ to $1{\cdot}28\,\mu$, depending on the amount of hammering the crystal had undergone.

A. W.

936. *Ionising Potentials of Argon, Neon, and Helium.* **H. C. Rentschler.** (Phys. Rev. 13. pp. 297–298, April, 1919. Abstract of paper read before the Am. Phys. Soc., March 1, 1919.)—Measurements of the resonance potential were made by the method first used by Tate in his work on mercury vapour. Ionising potentials were measured by Lenard's method, and also by measuring the current between a hot tungsten filament and a surrounding cylinder as a function of the potential between the cylinder and filament. Argon was found to have a resonance potential of about 12 volts and an ionising potential of about 17 volts. Neon shows no resonance potential. The ionising potential was found to be about 21 volts instead of 16 as determined by Franck and Hertz. This difference is possibly due to the greater purity of the neon used in the present experiments. Helium shows no resonance potential. The ionising potential was found to be about 27 volts instead of 20 volts as found by Franck and Hertz, Pawlow, and Bazzoni. This value is in close agreement with Bohr's theory and also with the value calculated by the quantum theory from the limit of the helium spectrum measured by Richardson and Bazzoni. Experiments are described showing the probable cause for the difference between the present and former experimental values.

A. W.

937. *Thermionic Amplifier.* **H. J. van der Bijl.** (Phys. Rev. 13. pp. 283–284, April, 1919. Abstract of paper read before the Am. Phys. Soc., April, 1918.)—A theoretical treatment applicable particularly to the vacuum-tube amplifier manufactured by the Western Electric Co. Formulæ are derived for voltage amplification, power amplification, and current amplification, which have been tested and found to hold with sufficient accuracy to serve for the computation of circuits involving thermionic amplifiers. The characteristic equation used is not sufficiently accurate to apply in the case in which the tube is used as a radio-detector. The detecting action of the tube depends on the second derivative of the characteristic, so that a more accurate characteristic equation is required. [See Abs. 1267 (1918).]

A. W.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

938. *Polarisation of Selenium Cells.* **H. Greinacher.** (Deutsch. Phys. Gesell., Verh. 19. pp. 51–71, April 30, 1917.)—Shows that all polarisation effects in selenium cells are independent of the effects produced by light. The apparent diminution of the polarisation of a cell on illumination is due to the change of resistance. The behaviour of selenium cells is the same as if they were in parallel with a cell capable of polarisation, or with a capacity, which may be very small. E. E. F.

939. *Conductivity of Molten Sealing-wax.* **G. Quincke.** (Ann. d. Physik, 58. 6. pp. 549–552, April 25, 1919.)—Describes a number of experiments which show that molten sealing-wax is a conductor of electricity. In some of the experiments one end of a metal wire was coated with molten sealing-wax and the wire was then attached to one pole of a Toepler or Holtz influence machine. The various phenomena observed are illustrated. A. W.

940. *Specific Conductivity of Earth's Crust.* **M. Abraham, H. R. v. Traubenberg** and **J. Pusch.** (Phys. Zeits. 20. pp. 145–147, April 1, 1919.)—Two parallel wires were used in the experiments described, one being fed with undamped oscillations from a valve transmitter, the other receiving the current through the earth. In frozen ground values for σ (specific conductivity, e.m. units) were obtained of 1·3 to $1{\cdot}14 \times 10^{-13}$, showing very little variation with the wave-length. In very damp earth σ varied from $8{\cdot}6 \times 10^{-14}$ for a 660-m. wave to $6{\cdot}5 \times 10^{-14}$ for an 1130-m. wave. In moderately damp ground there was again a variation of σ with the wave-length of the oscillations employed. For $\lambda = 610$ m., $\sigma = 8{\cdot}1 \times 10^{-14}$ and for $\lambda = 1170$ m., $\sigma = 7{\cdot}8 \times 10^{-14}$. Theory shows that the earth resistance should be proportional to $\surd(\lambda)$, and the results obtained for damp ground are in agreement with this. A. W.

941. *Thermo-E.M.F. of Some Alloys.* **M. A. Hunter** and **J. W. Bacon.** (Am. Electrochem. Soc., Trans. 33. pp. 183–196, 1918.)—Data are given for the thermo-e.m.f. of binary and ternary alloys of iron, nickel and copper with chromium and manganese, against iron. The wires of various alloys were joined directly to a standard iron-constantan thermo-couple by binding the junctions with soft Swedish iron wire. The thermo-e.m.f. of each individual wire was taken against the iron wire of the standard couple. The iron of this thermo-couple is a soft iron of low carbon content. In considering the commercial utility of any combination of metals for use in a thermo-couple the following considerations were taken as a basis for judging:—(*a*) The straightness of the e.m.f.-temperature curve and the absence of inversion points. (*b*) The reproducibility of the alloys and their permanency. (*c*) High melting-point. (*d*) Resistance to oxidation.

The investigation shows the two classes of useful alloys: (1) the Ni-Cr alloys, and (2) the Cu-Ni-Cr alloys. The alloys of the first group are already well known. The second class also give curves which are approximately straight lines for the e.m.f. against temperature. The materials have a high melting-point and resist oxidation well; further, large variations in composition have but little effect on the e.m.f. The copper-nickel concentration can vary between 75 Cu : 25 Ni and 50 Cu : 50 Ni. The max. e.m.f. would probably be obtained by using an alloy of 60 Cu : 40 Ni and adding Cr thereto.

When all the various factors are considered these experiments have disclosed that the best combination among those tried would be one containing Cu 50 : Ni 50 : Cr 20 or Cu 50 : Ni 50 : Cr 10 combined with Ni 100 : Cr 10. E. G.

942. *Some Properties of the Bolometer.* **E. Warburg** and **C. Müller**. (Deutsch. Phys. Gesell., Verh, 18. pp. 245–251, May 15, 1916. From the Physikal.-Techn. Reichsanstalt.)—Describe the results of tests (1) with the bolometer and envelope both black, (2) with bolometer black and envelope perfectly reflecting, etc. E. H. B

943. *Electric Conductivity of Liquid Metals and Alloys in Relation to Electron Concentration and Viscosity.* **F. Skaupy**. (Deutsch. Phys. Gesell., Verh. 18. pp. 252–260, May 15, 1916.)—Deals with various metals dissolved in mercury, such as, Li, Na, K, Rb, Cs, Ca, Ba, Tl, Zn, Cd, Bi, Sn, Pb, and Au. E. H. B.

944. *Electrical Precipitator for Analysing Smokes.* **R. C. Tolman, L. H. Reyerson, A. P. Brooks** and **H. D. Smyth**. (Am. Chem. Soc., J. 41. pp. 587–589, April, 1919.)—Describes an electrical precipitating apparatus for determining the concentration of smokes. The apparatus consists essentially of a modified Cottrell precipitator, with a central wire as kathode, surrounded by an anode consisting of a cylinder of Al-foil 0·001 in. thick. The smoke to be analysed is drawn through the apparatus at a known rate and the particles of smoke are precipitated on the foil by means of a high-voltage direct current. The determination of concentration is made by measuring the volume of air that passes through the apparatus and weighing the foil before and after precipitation. The high-voltage direct current is obtained by stepping up from 110 volts a.c., and then rectifying with a "Kenotron" valve. It is possible to use up to 15,000 volts without sparking if a threaded Pt-wire is employed. The use of a mechanical rectifier for the current leads to increased sparking. In general it is found possible to pull a fairly concentrated sample of smoke through the apparatus at a speed of about 5 litres per min. and to obtain complete precipitation. J. W. T. W.

945. *Use of Hot Kathode Tube for the Measurement of Voltage.* **L. P. Wheeler**. (Phys. Rev. 13. pp. 298–299, April, 1919. Abstract of paper read before the Am. Phys. Soc., March 1, 1919.)—Two general schemes of connection have been tried. In one the voltage to be measured is applied between the grid and filament of a 3-electrode tube and the change thus produced in the plate current observed. In the other, the voltage is introduced between the plate and filament of a 2-electrode tube and the resulting change in the plate current measured. A third method (for higher voltages) in which the voltage is applied between the plate and filament of a 3-electrode tube and the change in grid current measured is still under investigation. Only the results obtained by the first method are dealt with in the present paper. A compact portable apparatus has been made which serves for the measurement of low voltages (up to 50 volts) in a.c. circuits of any frequency. Such instruments have been found to hold their calibration well, and if properly used their indications can be made independent of wave-form as well as frequency. The various details are discussed. Thus the calibration must be carried out on a low-frequency a.c. circuit. It is essential that each battery should yield a constant current. Each tube requires individual adjustment, and until the manufacture of tubes has been better standardised these methods of measuring voltage are seriously handicapped. A. W.

946. *Permanent-contact Crystal Detectors.* **[Miss] L. S. McDowell.** (Phys. Rev. 13. pp. 288–289, April, 1919. Abstract of paper read before the Am. Phys. Soc., March 1, 1919.)—Describes an investigation of possible methods of securing a permanent-contact crystal detector. Various methods, including a.c. and d.c. electrolysis, soldering and welding, were tried, but all were unsuccessful with the more sensitive crystals such as galena and silicon, although partially successful with molybdenite and carborundum. The results point to the necessity of a high resistance at the contact, and suggest that with the more sensitive crystals the only satisfactory permanent-contact detector will be one with a mechanically maintained, high-resistance contact. A. W

ALTERNATING CURRENTS AND MAGNETISM.

947. *A Study of the Joule and Wiedemann Magnetostrictive Effects in the same Specimens of Nickel.* **S. R. Williams.** (Phys. Rev. 10. pp. 129–139, Aug., 1917. Paper read before the Am. Phys. Soc., Dec., 1912.)—Changes in length and twist on increasing the magnetic field were recorded continuously by a photographic method. Although the Joule and Wiedemann effects are primarily connected with one another, the relation between them is not so simple as it was regarded by Maxwell. In the Wiedemann-effect the direction of the lines of magnetisation due to the spiral field changes with increase of either the longitudinal or the circular component. The twist observed will depend on whether the magnitude of the spiral field is increased by keeping the circular field constant and increasing the longitudinal field, or *vice versa*. In the case of steel, the maximum of the Wiedemann-effect should occur at lower field strengths than the maximum of the Joule-effect. The importance of the presence of auxiliary fields when studying these phenomena is shown in the photographic records in the paper. The auxiliary vertical field of the earth is effective in the case of Ni, but is negligible with steel. The varied complexity of the results observed in different magnetic materials is ascribed by the author to the presence of intrinsic fields brought about by the varying initial orientation of the molecular magnets. L. L.

948. *Electron Theory applied to Magnetism and the Hall-effect.* **G. Borelius.** (Ann. d. Physik, 58. 6. pp. 489–504, April 25, 1919.)—In previous papers [Abs. 335, 336 (1919)] the author has discussed the phenomena of thermo-electricity and electrical and thermal conduction in metals, stress being laid on the part played by the positive atomic ions in the process. The author now elaborates his hypothesis. He depicts a space-lattice of positive atomic ions with an equal number of electrons interspersed. The atomic vibrations will influence the motion of the electrons and they are regarded as describing curved paths. The expressions derived for the thermal and electrical conductivities differ slightly from those in the previous paper [Abs. 336 (1919)]. The calculated value of the Wiedemann-Franz constant is $7{\cdot}8 \times 10^{10}$ e.m. units, and this agrees more nearly with the mean for twelve metals given by Jaeger and Diesselhorst, namely $7{\cdot}11 \times 10^{10}$. The effect of a magnetic field on the motion of the electrons is then considered and expressions are obtained for the radial and circular magnetic susceptibilities. The relative value of these components determines the para- or dia-magnetic quality of the metal. Comparison with experiment shows that Sb, Bi, and the ferromagnetic metals do not conform to the theory.

The Hall-effect is then treated and a positive and negative coefficient accounted for. L. L.

949. *Solar and Lunar Diurnal Variations of Terrestrial Magnetism.* **S. Chapman.** (Roy. Soc., Phil. Trans. 218. pp. 1-118, Feb. 5, 1919.)—A more complete account of the work dealt with in Abs. 341 (1919).

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

950. *Apparatus for Measuring Energy in Röntgen Radiation.* (German Pat. 296,448. Elektrot. u. Maschinenbau, 37. p. 124, March 23, 1919. Abstract.)—This arrangement, devised by the firm of Reiniger, Gebbert & Schall, is for measuring the amount of energy in the rays which pass through a certain area at right angles to the direction of the rays. It consists of an ionisation cell and an absorber, built upon it, which the rays must pass through before entering the cell. The penetrating power of the rays is not the same over the whole surface of entrance to the cell. According to the shape of the cell used and the absorber, and the absorption properties of the latter, the relative measure in which rays of different penetrating power contribute to the ionisation of the gas in the cell can be altered. By this means it is possible to ascertain the part played by rays of different penetrating powers in the total ionising action of the radiation. A. E. G.

951. *Protection in Diagnostic Work. The Effects of Scattered Rays and Secondary Rays.* **F. Hernaman-Johnson.** (Röntgen Soc., J. 15. pp. 45-50; Disc., pp. 50-52, April, 1919.)—In the best modern stands and couches, the observer is absolutely protected from the direct beam. But the scattered radiation remains, and is of the same penetration as the original beam. In very few cases is any attempt made to deal with this. It is not generally realised that the human body scatters X-rays just as translucent material scatters light. When a very small diaphragm is being used this scattering is negligible; but when a general view of the chest or abdomen is concerned, it is quite a different matter. In the present paper the upright screening stand, the X-ray couch, the X-ray proof "armour," and scattered rays and secondary rays are dealt with, and the following general conclusions arrived at:—The tube should be entirely enclosed in a box opaque to X-rays. The diaphragm leaves, and the lead glass in front of the screen, must also be opaque. The above is already conceded in principle, but by no means always carried out in practice. Scattered radiation should be prevented from reaching the body of the observer: (*a*) in the diascope by making the whole front opaque to X-rays; (*b*) in the couch, by a moving "panel" and by extensive flaps of lead rubber attached to the screen. True secondary radiation is not a danger, except in the case of certain metal articles worn close to the body, and then only if the precautions noted above are not efficiently carried out. A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

952. *Preparation of Argon in the Laboratory.* **M. Bodenstein** and **L[ili] Wachenheim.** (Ber. Deut. Chem. Gesell. 51. pp. 265–270, Feb. 9, 1918.)—All atmospheric oxygen contains argon, and the Griesheim Elektron. Gesell. (German Pat. 295,572 of 1913) isolate this argon. The laboratory process of the authors is based upon this patent, but they control the process by an additional manometer, instead of the tube of copper and copper oxide. The oxygen is burnt with hydrogen in a small quartz combustion chamber; the water formed is trapped in two condensers. Any nitrogen present in the gases (from steel cylinders fitted with Rossignol regulating valves) is eliminated by passing the gas finally through an iron tube charged with calcium turnings and maintained at 600°. A litre of argon can be prepared in 2 hours. H. B.

953. *Formation of Large Crystals in Zinc Rods and Wire.* **W. Fraenkel.** (Zeits. Elektrochem. 23. pp. 302–304, Oct. 1, 1917.)—With respect to Böttger's paper on large crystals in tungsten wire, the author points out that large crystals are known to develop in drawn zinc wires which then break, across or along an oblique plane of cleavage, and that the conditions can sometimes be initiated by heating zinc rods to temperatures just below melting and subsequent cooling; the fracture may disclose the presence of one or of several crystals. Lacroix found in Martinique, in houses ruined by the volcanic eruption, zinc nails consisting of one crystal. No satisfactory explanation is arrived at; the influence of impurities is not clear, and there is no evidence that zinc can allotropically be modified by inoculation. H. B.

954. *Occlusion of Hydrogen by the Metallic Elements and its Relation to Magnetic Properties.* **D. P. Smith.** (J. Phys. Chem. 23. pp. 186–202, March, 1919.)—Three types of combination of hydrogen with metals are distinguished by the author. The first type may be represented by the compound SbH_3, the second by the hydrides of the alkali and alkaline earth metals, whilst palladium-hydrogen is the classical example of the third type. If the elements are arranged according to the periodic classification of Werner, it is found that the metals which form compounds of Type 1 appear with the non-metals at the extreme right of the table. Metals which belong to the second type all appear at the left of the table, whilst those belonging to type 3 appear in the centre. From a consideration of the literature on the subject, the metals of type 3 are classified into those which do and those which do not occlude hydrogen in a degree measurable by the ordinary volumetric method. After this classification has been made it is shown, from a comparison with magnetic data, that the occluding and non-occluding elements, excepting Cu, Rh, and Th, are identical with those for which the specific magnetic susceptibility possesses a value respectively greater or less than approximately $+0{\cdot}9 \times 10^{-6}$ at room temperature. It is concluded that the capacity of a metal to occlude hydrogen in large degree is an accompaniment of strongly magnetic properties. T. S. P.

955. *Measuring the Velocity of Crystallisation of Metals.* **J. Czochralski.** (Zeits. Phys. Chem. 92. pp. 219–221, April 24, 1917.)—A rod of glass or quartz is lowered into the metal fused in a crucible; the rod is suspended by a silk thread over a pulley and drawn up at an adjustable rate by clockwork. When the metal is crystallising, a wire thread of the metal will adhere to the rod, and the rate at which the thread can be drawn up without breaking is read off. With tin, lead, zinc (melting at 232°, 320,°, 416°), the max. rates were 90, 140, 100 mm. per minute. The wires drawn were less than 1 mm. in thickness; by etching them it was shown that they consisted of single crystals, up to 150 mm. in length. H. B.

956. *Graphitic Carbon and Graphitic Acid.* **V. Kohlschütter and P. Haenni.** (Zeits. Anorg. and Allgem. Chem. 105. pp. 35–68, and 121–144, Jan., 1919. Chem. News, 118. p. 263, May 30, 1919. Abstract.)—All varieties of graphite and amorphous carbon are different physical forms of "black carbon" which is to be regarded as an allotropic modification of diamond. No sharp line of demarcation can physically or chemically be drawn between graphite, on the one hand, and soot on the other. All the reactions favouring the production are of the class of "topochemical" reactions and may be distinguished as (1) surface reactions, (2) reactions *in situ*, (3) surface layer reactions. (1) When acetylene is slowly decomposed by copper at 400° or 500°, graphite is produced; at higher temperature in unlimited space soot is the product. Examples of (2) are the Acheson process, decomposition of a carbide, and the segregation of graphite from iron-carbon solutions; in the latter case the decomposed crystals of cementite first formed seem to give rise to the formation of pseudomorphic graphite crystals. (3) When graphite is formed by reversible reactions such as the decomposition of carbon disulphide, the temperature determines the rate at which equilibrium is attained; otherwise temperature and pressure have little influence. In Nature graphite may have been produced by various reactions of these types, *e.g.*, by the metamorphosis of organic carbons in contact with igneous rock, and more frequently by the decomposition of carbon monoxide in clefts, favoured by catalysts (metallic oxides). The X-ray examination by Debye and Scherrer of the various modifications of carbon supports the view that there is no essential difference between graphite and amorphous carbon; the differences in the heats of combustion and densities are not incompatible with that view. There is no distinct graphite molecule; that graphitic acid can be obtained only by the oxidation of graphite, whilst amorphous carbon yields CO and CO_2, is due to the peculiar structure and dispersity of graphite, which determine the peculiar properties of graphite in general. As regards graphitic acid and oxide, different soots of graphite have been assumed to yield different oxidation products (brown, yellow to green); but the constitution of the acid is unknown, and even the composition uncertain. The authors first believed with Balbiano (1915) that graphitic acid was merely an adsorption product of graphite, CO, CO_2, and H_2O, but they do not maintain this, and the chief object of the researches (second paper) was to obtain a reproducible oxidation product. The oxidation is effected with a mixture of potassium chlorate and of nitric and sulphuric acids in the cold. The composition of the graphitic acid produced varied with the number of oxidations, from 59 C, 1·9 H, 39 O to 54·4 C, 2·1 H, 735 O, after 5 oxidations. The apparent crystals are merely pseudomorphs of the original graphite; the lighter-coloured products of repeated oxidation are more highly disperse, and the colour does not depend upon the original graphite. Reducing agents reduce the acid to carbon. Heating may lead to a final explosive decomposition which with slow heating may occur at low temperature or not at all; the resulting carbon (of 99·7 %) is sooty, but resembles graphite when compressed. Decomposition under sulphuric acid or 180° yields a carbon intermediate between soot and graphite. The experiments were made with electrically prepared graphite free from ash; when the acid is treated with metallic reducing agents, metal (iron, tin) is adsorbed and very difficult to remove again. H. B.

957. *Metallography of Aluminium.* **R. J. Anderson.** (Frank. Inst., J. 187. pp. 1–47, Jan., 1919.)—This paper deals mainly with the microstructure of different forms of aluminium, but a brief discussion of the amorphous theory and plastic deformation, and some observations on grain growth phenomena are included.

Cast Al consists of an aggregate of allotriomorphic crystals but well-defined dendritic structure is not uncommon. Commercial Al generally contains about 0·15 % Cu, 0·3 % Fe, and 0·3 % Si and when slowly cooled, the whole of the Cu is in solid solution; the iron forms a compound $FeAl_3$ which is only slightly, if at all, soluble in solid Al, while the Si exists partly as crystals of free Si and partly in solid solution. The effect of annealing cold-worked Al is dealt with and a number of photomicrographs illustrating the change of structure which takes place are given. It is shown that the greater part of the softening of hard-worked Al by annealing occurs very quickly, whereas complete softening may take a long time, depending on the annealing temperature.

Results indicate that it is easier to recrystallise deformed Al on heating when it contains little amorphous phase than when there is much present although it is not apparent why the amorphous phase has such remarkable thermal stability. Cases of exaggerated grain-growth are instanced, and it is shown that, in the case of a sheared sample, on annealing there were three zones of recrystallisation: (1) a zone of least strain where recrystallisation proceeds slowest, (2) a zone of greater strain where recrystallisation proceeds fastest, and (3) a zone of greatest strain where recrystallisation is slower than in (2) but faster than in (1).

When substantially pure Al or one of its ductile alloys is strained, slip bands are formed; but no twinning as the result of direct mechanical strain has so far been observed. Illustrations are given of slip bands in various specimens. An aqueous solution of hydrofluoric acid containing 8 %, is stated to be the most satisfactory etching solution. C. O. B.

958. *Constitution of the Copper-rich Aluminium-Copper Alloys.* **J. N. Greenwood.** (Engineering, 105. pp. 277–281, March 15; 310–312 and 314; Disc., 305–307, March 22, 1918. Paper read before the Inst. of Metals, March, 1918.)—The paper deals chiefly with the relationship of hardness to constitution and preliminary work was first carried out consisting of quenching the alloys, of varying composition, from different temperatures and determining the hardness of the quenched specimens by the Brinell and scleroscope methods. The effect of the various factors on the results obtained by these two instruments are given, and show that with coarse structures consisting of two constituents of widely different hardness, scleroscope tests must be carried out with great care and the average of a large number of tests taken. The effect on the Brinell is negligible. For Brinell tests, the specimens need not be thicker than 0·2 in. when a load of

1500 kg. is used; with the scleroscope, however, the results are erratic with this thickness, but are quite consistent with specimens of 0·4 in. and upwards. A wide variation in the smoothness of surface was found to be allowable for the scleroscope tests. The Brinell hardness number was found to increase with the load applied but became comparatively constant with a load of 3000 kg. and upwards. There was found to be a linear relationship between the hardness obtained with a load of 1500 kg. and the corresponding hardness obtained with a load of 3000 kg., the latter being obtained by multiplying the former by 1·06.

A series of experiments on quenching alloys containing 8·7 to 13·3 % Al showed that the ease with which the β solution could be retained, varied enormously with the composition, being easiest in the neighbourhood of the eutectoid point (12 % Al) and more difficult as the limits of its existence were approached. The alloys proved to be remarkably sluggish, and it was found that at 600° C. a period of 20 days was required to reach equilibrium.

An alloy containing 9·7 % Al can be obtained as the α-solution; it is necessary, therefore, to move the upper limit of the α-solution from the 9 % Al found by Curry to the neighbourhood of 9·7, as previously found by Carpenter and Ewards. The hardness–composition curve of the α-solutions is found to be linear, both by the Brinell and scleroscope; hence the idea that the upper limit of this series of solid solutions is formed by the compound Cu_4Al cannot be held.

The existence in the β-solutions of the compound Cu_3Al received confirmation, from the presence of a minimum in the hardness–composition curve corresponding with this phase.

The alloys consisting of the $\alpha + \beta$ mixtures depart considerably from a linear relationship with the composition when hardness is measured by the Brinell method, in the sense that they are harder than would be calculated from a linear equation, and the same remark applies to the $\alpha + \delta$ and $\beta + \delta$ mixtures.

The paper is illustrated by a number of curves, photomicrographs, and tables. C. O. B.

959. *Gold-rich Amalgams.* **N. Parravano and P. Jovanovich.** (Accad. Lincei, Atti, 27. ii. pp. 364–368, 1918.)—Previous investigations by various authors lead to the conclusion that in gold amalgams containing between about 90 % and 100 % Au, mercury exists dissolved in the gold to form solid solutions. In order more clearly to define the nature of these gold-rich amalgams, the authors have measured the electrical resistances at 25° of pure Au and of a series of twenty-one of the amalgams containing from 0·4859 % to 9·593 % Hg. These amalgams were prepared by coating a gold wire about 0·5 mm. in diam. electrolytically with mercury, heating the wire at 200° for 2 to 3 hours, then coating again with mercury and heating, this procedure being continued until the resulting amalgam assumed the desired composition. The homogeneity in composition of the amalgamated wires was demonstrated by microscopic examination and also by analysis. The specific conductivities of the different amalgams are given in the forms of a table and a curve, the latter showing a continuous diminution in the conductivity of gold by increasing proportions of mercury. This behaviour is characteristic for solid solutions. T. H. P

960. *Silver-rich Amalgams.* **N. Parravano and P. Jovanovich.** (Accad. Lincei, Atti, 27. ii. pp. 411–412, 1918.)—Silver amalgams rich in silver were prepared similarly to the gold amalgams [see preceding Abs.]. The specific electrical conductivity curve is not continuous, but consists of two distinct branches: the first extends from 0 to about 2 % Hg, and has the form characteristic of solid solutions. The second, from about 2 % to 14 % Hg (the highest proportion of mercury attainable by the method of preparation used), is a straight line, this being characteristic of alloys composed of two distinct crystalline individuals; the latter are the saturated mixed crystals with 2 % of mercury and, according to Reinders, the compound, Ag_3Hg.

T. H. P.

961. *Charge and Dimensions of Ions and Dispersoids.* **G. v. Hevesy.** (Kolloid Zeits. 21. pp. 129–136, Oct., 1917.)—The potential V of an ion in a diluted solution, in which it may be regarded as an isolated, charged sphere, is proportional to its charge e and indirectly proportional to its radius R; $V = e/kR$. The constancy of V is only possible if there correspond to an increase in the charge (valency), an increase in the size of the particle. The reality of this increase is proved by diffusion experiments which are for ions of 1, 2, 3, 4 valencies in the ratios 1:1·99:3·03 to 3·88; the increase is attained by an increased hydration. For a normal univalent ion $R = 2{\cdot}8 \times 10^{-8}$ cm., and there is, further, evidence supporting the view that there is a tendency for electrically-charged ions to combine with water until the potential of the particle is diminished to 70 millivolts. Complex organic ions do not incline to combination with water, and their anhydrous potential is already smaller than that which would result from the interaction. Taking $e = 4{\cdot}7 \times 10^{-10}$, the mobility of normal ions is 48, while the mobility of the abnormal complex ions has smaller values. In distinction from ions and their constant e/R, dispersoids are carriers of electricity of the nature of double-layers (Helmholtz-Smoluchowski); their size is *a priori* given (by the preparation of the colloid) and the double-layer assumes a charge such that the potential remains constant, $V = e(R_2 - R_1)/kR_1R_2$, where R_1 is the radius of the particle, and R_2 the radius of the double-layer; for small particles the increase in the charge varies approximately as R_1, but with particles of 10^{-4} already the increase in the charge is more rapid and proportional to R_1^2 nearly. The thickness of the double-layer is about 5×10^{-7} cm. In these calculations the mobility of the dispersoids is assumed to be of the same order as that of the normal ions; any deviations from the normal mobility become less marked as the temperature is raised. In concentrated solutions and especially in fused electrolytes (of very high ionic concentration) there is a scarcity of solvent, and the normal size of ions is not reached; hence Pb^{++} should in fused $PbCl_2$ have more than twice the mobility that it has in water. The partial discharge of an ion (Fe^{+++} into Fe^{++}) does not lead to a change in potential, because in that case the particle is in a position to compensate for the potential-change by giving up water. The partial discharge of the electric double-layer, by ionic adsorption, and *e.g.*, on addition of an electrolyte, is always accompanied by a drop of potential, because the size then remains practically unchanged. Since, further, the stability of colloids is connected with the presence of the double-layer which prevents coagulation, the potential drop is also accompanied by coagulation; numerical calculations are based upon Zsigmondy's observations on the coagulation of gold particles.

H. B.

962. *The Conductivity of Dispersoids.* **G. v. Hevesy.** (Kolloid Zeits. 21. pp. 136–138, Oct., 1917.)—The charge on the particles, and the conductivity, of colloidal solutions can be calculated from the number, size, and mobility of the particles. Assuming various sizes for the gold particles of 1 % solutions, on the other hand, the conductivity may be calculated, and the comparison with the observed conductivity admits of drawing conclusions as to the size and the charges carried after Helmholtz-Smoluchowski. The max. conducting power of colloidal metals probably remains below $0{\cdot}5 \times 10^{-5}$ mho; the radius R of the particle would then be 10^{-7} cm. This small conductivity is mainly due to the small number of particles. Non-metallic colloids may conduct better, but the conductivity of colloids seems always to be smaller than that of 0·0001-N salt solutions. The charge of a disperse particle is $(R/d + 1)$ times the charge of an ion of equal size, if $d = 5 \times 10^{-7}$ cm. be the thickness of the double-layer. H. B.

963. *X-ray Examination of Various Kinds of Silica.* **S. Kyropoulos.** (Zeits. Anorg. Chem. 99. pp. 197–200, June 21, 1917. Correction, *ibid.* p. 249, Aug. 16, 1917.)—The specimens of silica-quartz; cristobalite; quartz glass (fused); precipitated hydrated silica, as such or heated to 1300° for 2 hours; and a silica gel with 89 % of water prepared 5 years previously—are powdered to particles of $0{\cdot}5\,\mu$ or $1\,\mu$, compressed to rods in paper cylinders and exposed to X-rays for about 3 hours after the method of Debye and Scherrer. Characteristic differences are noticed in the systems of rings and interference rings obtained, and the calcined silica gel seemed partly to be converted into cristobalite. The numbers on the plate of photographs are in the reversed order, which is pointed out in the correction. H. B.

964. *Viscosity of Pure Liquids.* **S. Arrhenius.** (Nobel Inst., Meddel. 3. No. 20 [40 pp.], 1918.)—Reviewing the work of Thorpe and Rodger, Dunstan and Thole (relation between molecular weight and logarithmic viscosity in homologous series), O. Faust (influence of pressure), P. Phillips [carbon dioxide, Abs. 1800 (1912)], A. W. Porter [fluidity, Abs. 1017 (1912)] and others, and recalculating the results by the formulæ of van der Waals and Tammann, the author concludes that the quantity $10^5\eta/\sqrt{s}$, where η is the viscosity and s the density at the boiling-point, varies between 280 and 320 for non-associated organic liquids, except in a few cases in which the value $k_1 = T^2 d \log \eta \,.\, v^{1/2}/dt$ [$v =$ spec. volume] does not show a minimum below the boiling-point (carbon tetrachloride, benzene, ethylene). The presence of negative atoms (halogens, oxygen, sulphur) increases the value $\eta/\sqrt{s}$; k_1 is nearly proportional to the absolute temperature T_b at the boiling-point, and the ratio k_1/T_b nearly constant (1 or 1·2) except for tetrachloride, etc. A linear formula is deduced for the change of the viscosity with pressure in non-associated liquids; also a formula for the influence of temperature. At high pressures the viscosity increase is nearly exponential; in the interior of the earth the magma would hence behave like a solid. For associated liquids k_1/T_b has higher values, ranging from 1·25 to 4·32. In homologous series this ratio generally increases with higher boiling-point. There is therefore an analogy between the temperature-change of the vapour pressure and that of the product of viscosity and specific volume. H. B.

965. *Anisotropic Colloidal Solutions.* **W. Reinders.** (Kolloid Zeits. 21. pp. 161–165, Nov.–Dec., 1917.)—Diesselhorst and Freundlich and Kruyt [Abs. 671 and 1119 (1916)] having observed that colloidal solutions of vanadium pentoxide display double refraction, further experiments were made which tend to show that the particles of such sols turn crystalline.

The double-refractive power is at ordinary temperature developed very slowly, rapidly at 100°, and there is no clear distinction between the isotropic sol and the microscopic crystalline particles. When colloidal solutions of PbI_2 or HgCl are prepared by mutual decomposition in the presence of a protective colloid there is a continuous transition from the colloidal state to the state of a doubly-refractive crystalline suspension. V_2O_5 can be obtained from aqueous solutions in the form of small needles; the ultramicrons of the freshly-prepared V_2O_5 sol become elongated on heating, and very probably the double-refraction develops simultaneously with the needle-ultramicrons. H. B.

966. *Colloidal Matter and its Properties.* **A. Findlay.** (Engineering, 107. p. 589, May 9, 1919. Abstract of two lectures delivered at the Roy. Inst., April, 1919.)

967. *Determining the Coefficient of Diffusion of Electrolytes.* **S. Procopiu.** (Ann. de Physique [ix] 9. pp. 96–112, Jan.–Feb., 1918.)—Fick's formula for the diffusion of a soluble substance into its solvent is based upon Fourier's theory of thermal propagation, and measurements can be based upon the observation of the variation with time in some physical or chemical property through a horizontal layer of a known thickness. The author uses the determination of the e.m.f. and a glass cylinder, 25 cm. high, 6 cm. diam., through the bottom of which two electrodes extend into the liquid to different levels, while a concentrated solution of the substance is introduced from the top through a capillary reaching almost to the bottom of the cylinder. The time interval required to let the e.m.f. attain its maximum is measured. The only experiments mentioned were made with copper sulphate at high dilution; the accuracy obtained ranged from 2 to 5 %. It is claimed that a very much higher accuracy could be realised, and the method is recommended for very highly-diluted solutions. H. B.

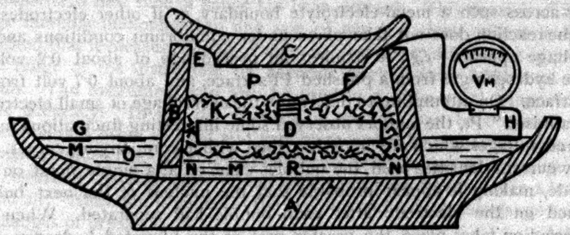
968. *Osmotic-Kinetic Theory of Dilute Solutions.* **K. Jellinek.** (Zeits. Phys. Chem. 92. pp. 169–212, April 24, 1917.)—The author confines himself in this deduction based upon Boltzmann and van der Waals to the simplest case of highly diluted solutions of non-electrolytes and makes two fundamental assumptions: (1) that the volumina of the pure liquid solvent and of the pure solid solute are added to the volume of the solution, and (2) that the volume corrections for solvent and solute are also additive. From these assumptions follows the equality of the thermal pressure of the pure solvent and of the diluted solution at equal external pressure and temperature, and the relations between osmotic pressure, concentration, temperature, and the laws concerning the lowering of the freezing-point and vapour pressure and the rise of the boiling-point can be deduced.

That the laws of diffusion can be treated kinetically has been proved by E. Riecke. But the equations of van der Waals are inadequate, and all attempts of a kinetic solution theory remain kinetic interpretations so long as we do not possess a real kinetic theory of pure liquids. H. B.

969. *Conductivity of Weakly-dissociated Neutral Salts.* **O. Svanberg.** (Nobel Inst. Meddel. 3. No. 26. [7 pp.] April, 1918.)—Measurements by Kohlrausch's bridge method of the conductivity between 0 and 65° of aqueous solutions of potassium stibo-tartrate (emetic tartrate) and copper acetate (semi-electrolytes) within the concentration limits 1/4 and

1/1024 N. The molecular conductivity of the tartrate increases within the dilution-limits stated by 220 %, rapidly at high dilution; the results favour neither the assumption of Clarke and Evans that the acid is monobasic, nor that of Hädrich that there is hydrolysis into acid potassium tartrate and *meta*-antimonious acid. The conductivity-increase with temperature is 2·8 to 2·4 % per 1 deg. and strictly linear between 25° and 65°. In the case of cupric acetate the temperature coefficient is 2 %, but above 40° the solution becomes turbid by the formation of hydrate; the increase with high dilution is still stronger than in the former case (sevenfold). H. B.

970. *An Experimental Carbon Cell.* **S. A. Reed.** (Am. Electrochem. Soc., Trans. 33. pp. 89–94, 1918.)—The author lays down the following principles as being desirable in the case of a carbon-consuming cell: (1) The electrolyte must not be consumed in the operation of the cell; (2) the electrodes must not be consumed in the normal operation of the cell; (3) no air-blowing or other mechanical attachment should be allowed, and (4) the gaseous product of the cell must have a free escape. For experimental purposes a cell fulfilling these conditions is obtained by using fused borax as an electrolyte, having in solution oxides of manganese. A convenient proportion is 80 % of powdered fused borax and 20 % of powdered "heavy" manganese dioxide. These are fused together and then powdered up so as to be in a convenient form for use. A section of the cell is shown in the accompanying diagram. A roasting dish is used as a container, and within a section of a Battersea crucible are placed lumps of anthracite, K. Embedded in the anthracite is a graphite plate D, which acts as a terminal. The other electrode consists of gold-foil, G. The anthracite reduces the manganese peroxide which gradually finds its way back into the upper part of the dish where it is re-oxidised by the air. The upper surface of the anthracite is exposed only to CO and CO_2 so that oxidation only occurs at the lower immersed surface. Such a cell is found to give an e.m.f. of about 0·9 volt with a coal surface of 8 sq. in. and oxidising surface of 14 sq. in. (the roasting dish being 6 in. in diameter). The current on closing circuit was found on the average to be 0·184 amp. falling to 0·172 amp. after one hour through 4½ ohms. The internal resistance averaged 5 ohms per sq. in. of carbon contact with the electrode.



W. R. C.

971. *Validity of Faraday's Law for Flame Electrolytes.* **B. Thieme.** (Deutsch. Phys. Gesell., Verh. 18. pp. 187–194, April 15, 1916.)—Experiments are described in which the quantity of carbon deposited by the passage of a current through a hydrocarbon flame has been measured. The best results are obtained when the air supply is only just sufficient to prevent the separation of soot. As the mean of several experiments with different current strengths, it is found that the quantity of electrolytically-deposited carbon is in fair agreement with the requirements of Faraday's law if the carbon atoms are supposed to carry a single unit of charge. [See Abs. 540, 1425 (1912).]

T. S. P.

972. *Faraday's Law and the Electrolytic Separation of Coppe*r *from Flames.* **B. Thieme.** (Deutsch. Phys. Gesell., Verh. 18. pp. 221–229, April 30, 1916.)—From experiments made with a flame sprayed with a solution of copper sulphate it is found that copper is deposited by an electric current passed through the flame in quantities agreeing with Faraday's law. [See Abs. 596 (1916).]

T. S. P.

973. *Hydrogen Overvoltage.* **D. A. MacInnes** and **L. Adler.** (Nat. Acad. Sci., Proc. 5. pp. 160–163, May, 1919.)—Hydrogen overvoltage is defined as the difference of potential that exists between a reversible hydrogen electrode and an electrode, in the same solution, at which hydrogen, H_2, is being formed from hydrogen ions. A reversible hydrogen electrode is one at which the reaction, $2H^+ + 2\varepsilon = H_2$($\varepsilon$ = electron), has reached equilibrium. This equilibrium is attained, and maintained during the passage of very small currents, only on electrodes covered with a dispersed "noble" metal, such as platinum. If stronger currents are passed across such a metal-electrolyte boundary, or if other electrodes are used, the reaction does not take place under equilibrium conditions and an overvoltage appears; *e.g.*, it requires an overvoltage of about 0·2 volt to liberate hydrogen gas from a polished Pt-surface, and about 0·7 volt from a lead surface. On attempting to determine the overvoltage of small electrodes of "platinised" Pt, the authors observed some interesting fluctuations in the measured voltages which are here described with accompanying curves. At the low current densities used, the bubbles came off at a single point on the electrode, making it appear probable that the nucleus of the next bubble remained on the electrode after each bubble had separated. When the above reaction takes place, the greater part of the liberated hydrogen goes direct into solution, and unless carried away by diffusion, stirring, or other means, produces a layer in immediate contact with the electrode, which layer is responsible for the overvoltage. If, however, there is a nucleus of gaseous hydrogen on the electrode, a portion of the liberated hydrogen will enter this gaseous phase, so that a gaseous nucleus will play a similar rôle to that of a small crystal in a supersaturated salt solution. An explanation of the voltage fluctuations is then given from the standpoint of the presence of dissolved and gaseous hydrogen about the electrode. It appears probable that the factor which determines the overvoltage of an electrode at any one pressure, is the size of the gaseous nuclei that can cling to it. A number of observers have called attention to the fact that electrodes with low overvoltages are those that have large adsorption powers. This adsorptive power is undoubtedly related to the attraction of an electrode for a gaseous nucleus.

H. H. Ho.